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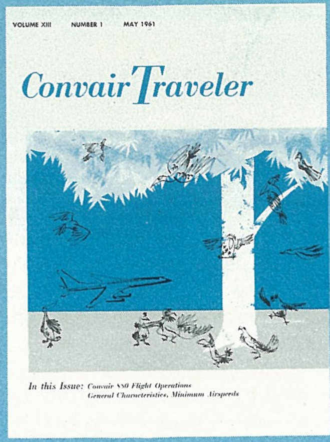
Convair Traveler

In this Issue: *Convair 880 Flight Operations*
General Characteristics, Minimum Airspeeds



OUR COVER

Artist Willis Goldsmith's birds have decided the "880" is too tame. It doesn't fly sideways, backwards, wrong side out, or upside down — standard maneuvers for Mr. G's birds. Flying right-side-up and level, the birds hold, is for the airplanes.

Convair Traveler

VOLUME XIII NUMBER 1 MAY 1961

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IN THIS ISSUE

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Convair 880 Flight Operations

general characteristics, minimum airspeeds

Yesterday's aircraft were often flown by the seat of the pants; tomorrow's may be flown by an electronic robot. But today's big jet airliners, including the Convair 880, are flown "by the book" and "by the numbers."

"The book" begins with some hundreds of pages of Civil Air Regulations – CAM 4b, 40, 41, 42, SR-422B. This is quasi-legal matter, impossible for most pilots to retain in toto, but useful to be acquainted with. Then, there is the FAA-approved Flight Manual, which may be termed, "The Word," so far as the particular type of aircraft is concerned. Also, that is where the "numbers" are — airspeed limits, climb gradients, and the like. On top of these, there are FAA directives and company flight rules.

Flying being still a skill rather than a body of technical knowledge, a lot that a pilot has to know is not in print. The book does not cover how much rudder it takes to hold against an "engine-out" condition — that has to be felt. But there is a considerable amount of valid information that is not in any of the official manuals and yet can be properly documented. It is some of this information, collected from engineering reports and experience in Convair test and training programs, that is being presented in this series of Traveler articles on flying the "880."

THE SWEPT-WING TRANSPORT

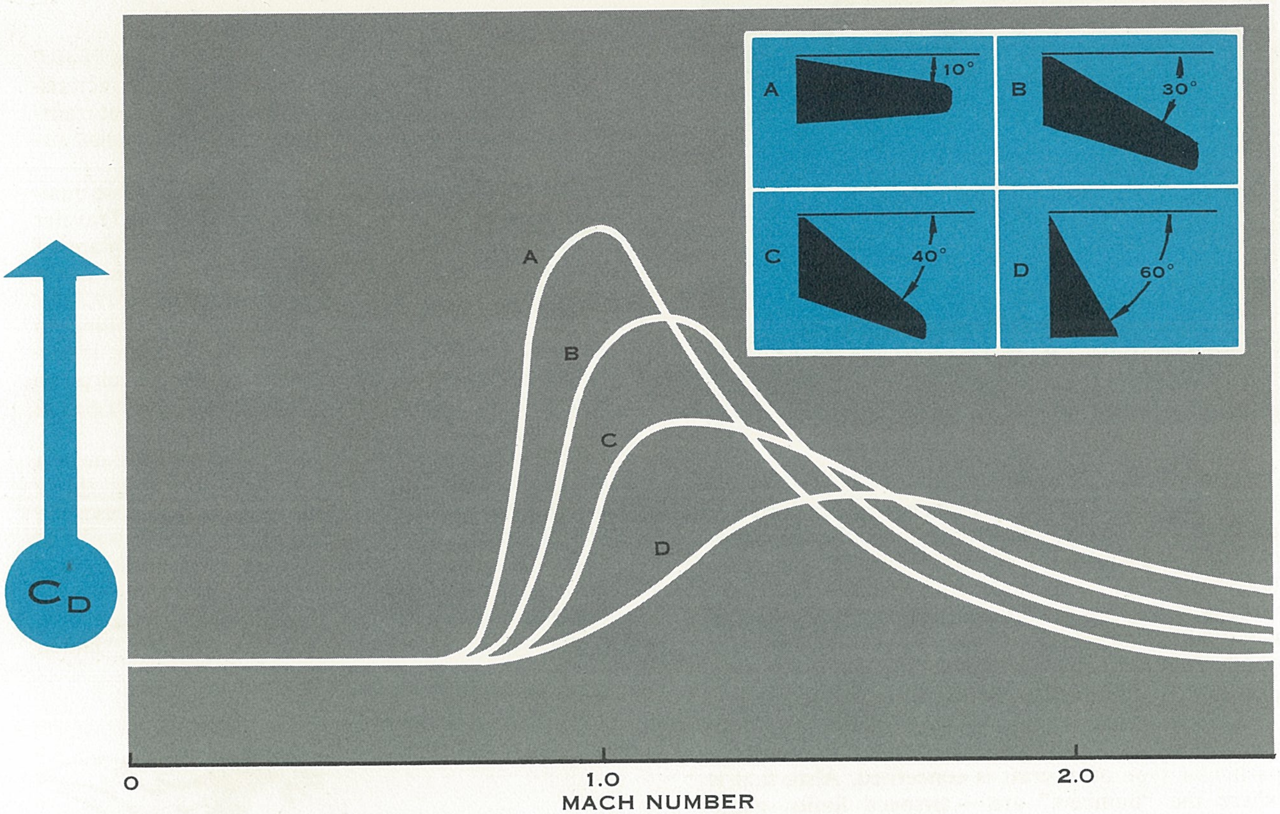
Before taking up specific aspects of flying an "880," it may be well to point out some general characteristics of the present-day swept-wing high-speed jet transports, in comparison with conventional propeller aircraft.

They differ considerably in basic aerodynamic qualities. Several years ago, it was pointed out in Traveler articles on Convair-Liners that the typical airplane of that configuration was designed for the utmost directional stability, at the expense of lateral stability. This required a minimum of pilot effort in controlling an airplane in engine-out takeoff or flight. Also, if disturbed by rough air, the tendency of such an airplane is to roll and sideslip in the direction of roll, in a relatively smooth maneuver.

The swept-wing jets have an opposite imbalance in directional-vs-lateral stability: they are more stable laterally but less stable directionally. This increases the asymmetric effect of loss of thrust in engine-out operation. If disturbed by a side gust or a rudder kick, they may enter into a somewhat disconcerting oscillatory roll-yaw motion, said to have been compared to a Dutchman on ice skates — whence the term "Dutch

roll." The initial yaw causes the advancing wing to lift, but its added drag causes the airplane to yaw toward the upwing side. The other wing is then advancing, reversing the roll, and the cycle repeats, unless damped by the basic stability of the airplane or by a control input.

Swept-wing aircraft are inherently more sensitive to lateral control input; roll rates are higher. They are at least as sensitive as propeller aircraft to pitch correction, and may seem to be more so because at high speeds it is harder to maintain a fixed altitude. At 550 kts, a little change in pitch makes twice the change in altitude that it does at 275 kts.



Typical curves, coefficient of drag vs Mach number, for straight wing (A), slightly swept wing (B), wing swept at approximate angle of "880" (C), and delta wing (D). Note that sweepback delays onset of compressibility drag in high subsonic range, but loses some of its value as speeds increase beyond Mach 1.5.

Lack of propeller-wash over the wings makes a difference in the feel of the airplane in sudden engine power application, as in a go-around. The "880" CJ-805-3 engine accelerates faster than two-spool types and reaches maximum thrust from approach rpm in two or three seconds; but the aerodynamic effect has to await airplane acceleration.

Another characteristic of the new generation of jet transports is the high angle of attack necessary in low-speed flight. While this is typical of high-speed aircraft generally, it is particularly true of aircraft with lower aspect ratios. The angle of attack brings in the tail-dragging possibility, and limits roll angle in strong crosswind landings.

Most important of all are the exacting requirements for piloting. This is in spite of the fact that current regulations provide more margin than ever before. There is now, for example, a 15% field length margin to provide for delayed rotation or slow rate of rotation; and demonstrations are required to prove that Flight Manual field lengths will not be exceeded if rotation is initiated 10 kts early for normal takeoffs, and 5 kts early with one engine inoperative.

Piloting jet aircraft demands concentration and precision flying because of the speed at which things are happening. At high gross weights, the V_R speed of the "880" may approach 300 ft per second; at light weights, acceleration rate at V_R may be 5 kts per second.

The safety margins are present only when observing the speeds specified in the Flight Manual. When gross weight is limited by runway length, a one-engine-inoperative takeoff at faster than normal rotation speed would lower the altitude attained over the end of the runway. More serious, rotation at much less than the 5-kt margin determined during test and certification indicates liftoff might be impossible within the limits of the runway.

Since takeoff and landing are very much concerned with specified speeds, a summary of CAR definitions and requirements is presented with some of their applications to specific "880" performance.

DEFINITIONS

V_S — **Stalling Speed:** the minimum steady flight speed at which the airplane is controllable with zero thrust, CG most unfavorable, and with weight and airplane configuration as applicable to determine compliance with a particular requirement.

V_{MCA} — **Minimum Directional Control Speed Airborne:** the speed at which, when the most critical engine is suddenly made inoperative, it is possible to recover control of the aircraft and maintain it in straight flight at that speed with an angle of bank not in excess of 5°; with engines at maximum available thrust, CG most unfavorable, landing gear up, flaps in takeoff position, and the airplane trimmed for takeoff.

V_{MCG} — **Minimum Directional Control Speed on the Ground:** the minimum speed at which controllability by primary aerodynamic controls alone is demonstrated during the takeoff run to be adequate to permit proceeding safely with the takeoff when the most critical engine is suddenly made inoperative. V_{MCG}, it must be remembered, is an airspeed, not a ground speed.

V_{MU} — **Minimum Unstick Speed:** the speed at and above which the airplane can be made to lift off the ground and to continue the takeoff without displaying any hazardous characteristics.

V_{LOF} — **Liftoff Speed:** the speed at which the airplane becomes airborne.

V_1 — **Critical Engine Failure Speed:** when gross weight is limited by runway length, the speed at which, if an engine fails, the airplane can be brought to a stop using maximum wheel braking and spoilers; and at which it is also possible to continue to take off and attain a height of at least 35 ft over the end of the runway.

V_2 — **Takeoff Safety Speed:** the speed attained at a height of 35 ft, assuming engine failure at V_1 and rotation at the proper V_R speed.

V_R — **Rotation Speed:** the speed at which the pilot applies force on the control column to initiate liftoff.

IAS — Indicated Airspeed, as it appears on the airspeed indicator. Flight manual IAS assumes no mechanical error in the instrument.

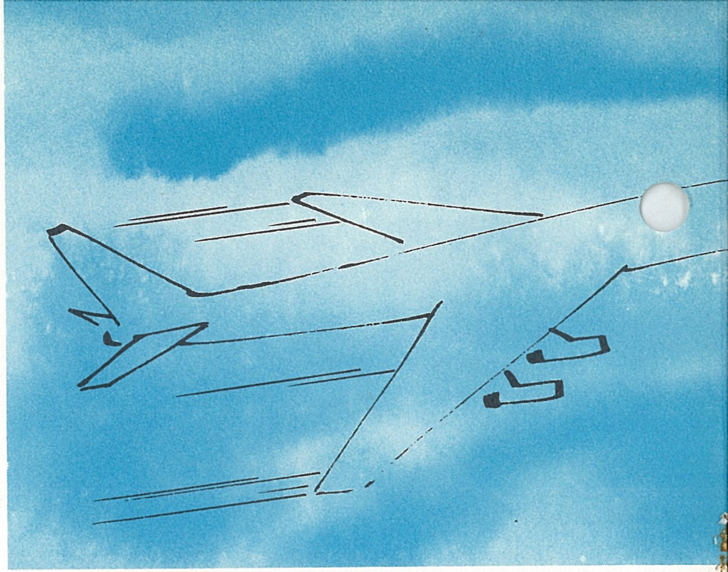
CAS — Calibrated Airspeed: indicated airspeed corrected for position error (airplane attitude, ground effect, etc.).

TAS — True Airspeed, relative to ambient air.

GS — Ground Speed: speed with reference to the ground, either airborne or groundborne.

M — Mach Number: ratio of airspeed to the speed of sound.

M_i — Indicated Mach Number, as shown on the Mach indicator.



The "880" V's

Some of the airspeed terms accompanying this article have been used in the past for reciprocating-engine aircraft, but may have changed definitions for jet aircraft. Other speeds have been added, because of changes in regulations and requirements peculiar to jets. Two speeds, V_{MU} and V_{LOF}, appear in the Civil Air Regulations but not in the flight manual. These speeds are determined during aircraft certification and form the basis for calculating minimum rotation speeds. V_{MU} and V_{LOF} lose significance for normal operation after V_R has been determined.

Stalling speed definition is the same as for reciprocating-engine aircraft. Stall speeds are determined during the flight test program under various conditions of weight, CG, wing flap position, landing gear position, and thrust. For the Flight Manual, they have been corrected to a forward CG, an approach rate of one knot per second, and zero thrust. For the "880," zero thrust has much smaller effect on stall speed than in propeller-equipped aircraft because of the lack of propeller-driven airflow over the wings, and landing gear position has negligible effect.

With wing flaps up, V_S for the "880" varies between approximately 112 and 151 kts IAS, depending on gross weight. It is 7 to 9 kts IAS lower with 20° takeoff flap setting. In landing configuration, with 50° flap extension and maximum landing weight, stall speed is 11 kts lower than with flaps retracted. The significance of stall speeds is that, with appropriate FAA safety margins, they determine minimum speeds for takeoff climbs and landing approaches.

Minimum takeoff speeds — V_1, V_R and V_2 — are also based on minimum control speeds. V_{MCA} and V_{MCG} are set with reference to the engine-out emergency, and are dependent on the directional control available to compensate for sudden loss of an engine. The factors that cause the greatest asymmetry in thrust, therefore, are the factors that establish V_{MC} speeds. Anything that increases the thrust-to-weight ratio increases the asymmetry: less weight, or more power. The most asymmetric thrust, then, and the highest minimum control speeds, are found with light weight, low altitude, and low temperature. V_{MCA} and V_{MCG} on a cold day at sea level are appreciably higher than on a hot day at altitude.

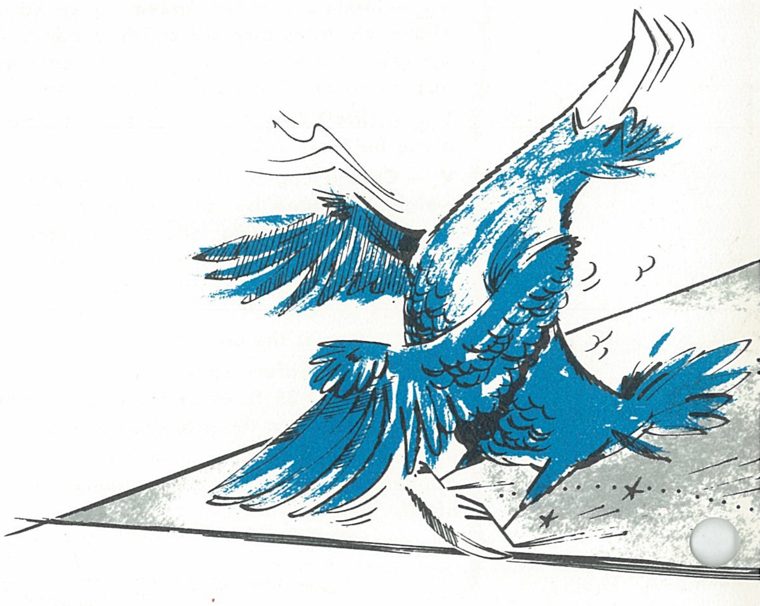
In the light-to-medium weight range, minimum control speeds determine minimum takeoff speeds. FAA certification testing for these speeds is conducted within this weight range. At heavy gross weights, stall speeds may be above tested minimum control speeds. In this area, V_S rather than V_{MC} is the determining factor for the takeoff minimum speeds.

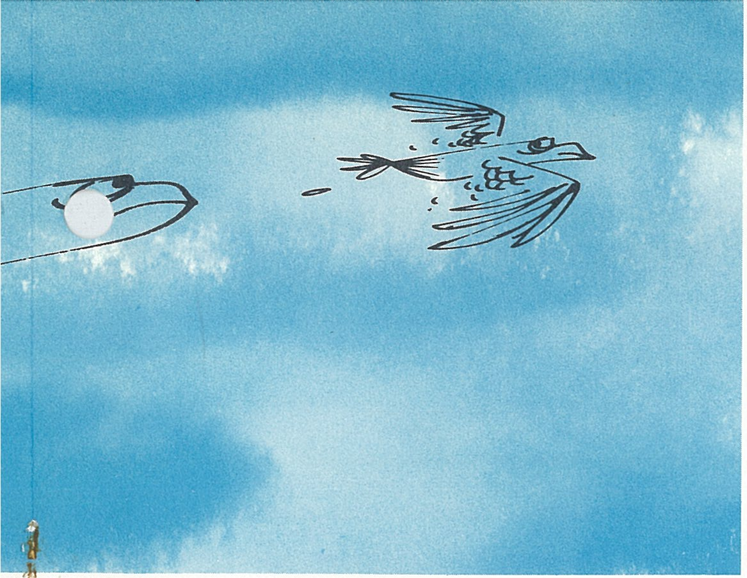
The definition of V_1 is slightly changed from that previously used for reciprocating-engine aircraft. In the past, it was the speed at which the engine failed; currently, the Flight Manual includes an increment of speed for pilot recognition of the failure, this increment having been determined during the certification program.

When gross weight is limited by runway length, it should be possible to stop at V_1 within the confines of the runway, using maximum braking and spoilers. Use of reverse thrust was not included in the stopping tests and therefore provides an additional margin for such variables as runway surface condition. At V_1 speed, with one engine inoperative, it is also possible to continue the takeoff and clear the end of the runway by at least 35 ft. An engine failure beyond V_1 may make a stop impossible when runway is limited, but will provide greater height clearance at the end of the runway. Continuing a takeoff attempt, after an engine failure below V_1, is not recommended; there is a point below V_1 which would result in complete inability to lift off before reaching the runway end.

V_1 must not be lower than V_{MCG}. This factor is limiting at gross weights below approximately 145,000 lb at sea level and standard temperature. On the page for V_1 in the Flight Manual, a separate chart is provided for determining V_{MCG}. The speed from this chart must be compared with the speed from the normal V_1 chart and, if greater, used in its place. Stopping distances are based on this higher speed.

The Civil Air Regulations state that V_1 speeds cannot result in greater brake energy absorption than was tested during certification. Thus, under conditions of high weight combined with high temperatures, alti-

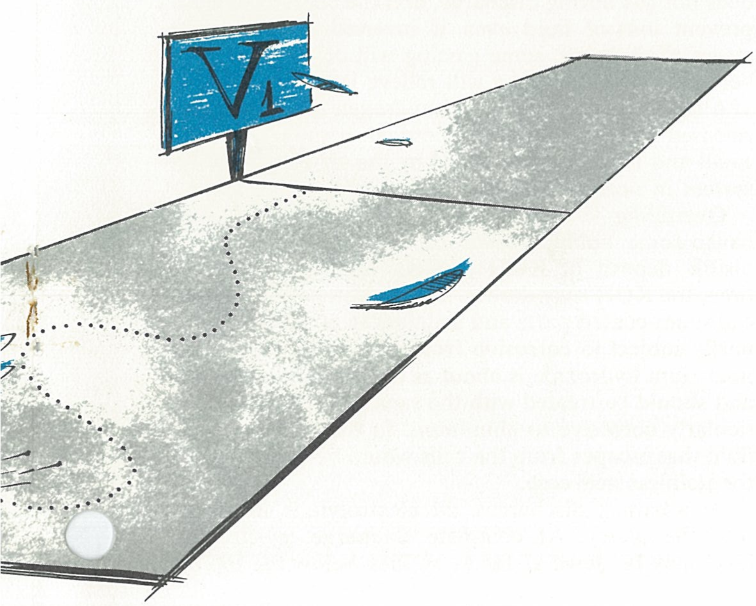




tudes, and/or tailwinds, maximum V_1 speed may be limited by brake capacity. V_1 speeds with nose brakes inoperative have also been provided for in Flight Manual charts. The speeds range from 2 to 4 knots lower, with appropriate field length curves provided.

Rotation speed, V_R, is limited by the higher of either 1.05 V_{MCA} or the limits resulting from the V_{MU} tests during certification. At light-to-medium weights (below 145,000 lb at sea level and standard temperature), V_R is equal to 1.05 V_{MCA}. At higher weights, V_R must be high enough so that even at maximum rotation rate, the resulting liftoff speeds will not be lower than the V_{MU} restrictions. For the "880," this liftoff speed is 1.05 V_{MU} with one engine inoperative. The "880" demonstrated that rotation at 10 kts below minimum V_R with all engines operating, and at 5 kts below with one engine inoperative, required no increase in field length. Failure to meet these conditions would have necessitated raising V_R beyond the speed determined by the V_{MU} testing.

The foregoing V_1 and V_R limits determined "880" field lengths. At the light-to-medium gross weights, field length is equal to the accelerate-stop distance, which was determined by V_1, defined by V_{MCG}. At higher weights, field lengths were determined by the requirement that, when the airplane is rotated at normal V_R with all engines operating, the Flight Manual field length must be at least 1.15 times the resulting takeoff distance to 35 ft height. In this area, V_1 was adjusted to make the accelerate-stop distance equal to 1.15 times the four-engine takeoff distance. This combination of V_1 and V_R results in a three-engine takeoff distance slightly shorter than the required field length shown in the Flight Manual.



V_2, the takeoff safety speed, no longer has quite the same meaning it had with reciprocating-engine aircraft, when it was considered to be the speed at liftoff as well as during takeoff climb. With jet aircraft, V_2 is the resultant speed at 35 ft height obtained after an engine fails at V_1 and the aircraft is rotated at a normal rate at V_R. As the airplane is accelerating throughout the takeoff maneuver, the liftoff speed will be less than V_2. Since liftoff speed is a transient condition, it is not considered to be of any practical significance and is omitted from the Flight Manual.

Regulations require that V_R must be increased if V_2 falls below either 1.1 V_{MCA} or 1.2 V_S. With the available acceleration of the "880" at the weights where $V_R = 1.05\ V_{MCA}$, the speed at 35 ft is well above 1.1 V_{MCA} and this requirement becomes academic. At higher weights, V_R is determined by V_{MU} requirements, and the resultant speed at 35 ft is also above the limit of 1.2 V_S.

It should be noted that V_2 speed is applicable only in connection with operation with one engine inoperative. There is no FAA-defined climb speed for the all-engine case. With normal V_R and elevator control input, the speed at 35 ft will be greater than V_2 when all engines are operating. Attempting to maintain V_2 speed in the normal takeoff will require abnormally large control inputs, and will result in uncomfortably high deck angle, with the possibility of slight buffet because of the load factor involved. With an engine inoperative, however, takeoff climbs should be made at V_2 until all obstructions are cleared. The takeoff flight path curves in the Flight Manual are based on use of V_2 airspeed until an altitude of 1500 ft is obtained. This is the altitude where, by FAA definition, the transition is made from takeoff to enroute climb. When obstructions are not limiting, the actual transition to enroute climb angle and airspeed can be made at any time.

One additional speed limit must be taken into consideration in determining maximum takeoff weights for the "880." The rated ground-roll limit speed for the Type VII tires is 200 mph (173 kts). Maximum tire speed occurs at liftoff during a four-engine takeoff. The resulting ground speed is then a function of gross weight, altitude, temperature, and runway wind component — all factors taken into account in the takeoff field length charts in the Flight Manual. Therefore, to eliminate the necessity for checking V_{LOF}, curves to determine tire-limited gross weights have been superimposed on the takeoff field length charts. The specific parameter in which the limit is expressed is in allowable wind component. On the chart temperature curves, a second head-tail-wind correction appears. If wind component is more unfavorable than that arrived at, gross weight must be reduced accordingly.

NICKEL-CADMIUM BATTERIES

BATTERIES IN THE CONVAIR 880/990 jet airliners are intended for emergency and standby use only. It now appears that they are being used a little more than that, principally in ground checkout of elements supplied by the DC emergency bus. However, normal DC power is supplied by the four transformer-rectifier units operating from the AC generators, and only a multiple malfunction of all four sources would require actual use of the battery in flight operations.

For such needs, the 13.5-ampere-hour Sonotone nickel cadmium storage battery in the Convair 880/990 has a number of advantages. It is lightweight and small . . . the 22-cell battery weighs only 37 pounds. and is approximately the size of a heavy-duty automobile battery. It is built for long life and can stand hundreds of charge-discharge cycles without deterioration. Operating temperatures are from —40° to 165°F . . . —65°F will not damage it. Since it does not develop heat or excessive gas, the caps are sealed with O-rings so that the cells will not leak in normal operation. It can be stored wet or dry, charged, discharged, or short-circuited. It is highly resistant to vibration and shock, and is not damaged by rapid discharge or reverse charge.

Six small emergency portable lights, stowed in the cabin over the emergency exits, and one in the flight compartment, are each powered by a small two-cell nickel-cadmium battery supply, kept on trickle charge all the time the airplane is in operation.

In the nickel-cadmium battery, both positive and negative plates are built up in manufacture by sintering nickel powder on a nickel screen frame. The active materials are nickel oxide on the positive plates, and cadmium oxide on negative plates. The oxides are deposited on the porous sintered plates by electrochemical means. A continuous three-layer strip of woven nylon and cellophane is folded back and forth between the plates to form a separator.

In the emergency DC power battery, compact nylon cells are enclosed in a stainless steel battery box. Since plates are sintered and the active material is an electrolytic plating, there is no flaking, and hence no need for space at the bottom for debris of the kind that accumulates in lead-acid batteries. The plates in the 880/990 aircraft battery are designed for high-current service and operation at low temperatures.

The electrolyte is a 30%-by-weight solution of potassium hydroxide (KOH). Charging a nickel-cadmium battery is a process of ionic exchange between the plates, and involves no chemical change in the electrolyte itself; the solution remains practically at a constant specific gravity. In charging, oxygen is removed from the positive plates (leaving metallic cadmium) and added to the nickel oxide, bringing it to a higher state of oxidation. Discharge reverses the process. Cell potential is nominally 1.27 to 1.3 volts, though at room temperature a single cell may show up to 1.7 volts at full charge. Internal resistance is low; therefore, high discharge rates are possible.

In Convair jet airliners, the battery is charged at 29.25 to 33.25 charging voltage by a 20-ampere transformer-rectifier unit. Initial charging rate is high, dropping as the battery voltage builds up. In discharge, voltage will remain almost level until the battery is near total discharge. This characteristic makes it particularly adaptable for emergency standby use; sufficient voltage to operate emergency equipment, including VHF communications radio, will be available during a relatively large proportion of the total discharge time.

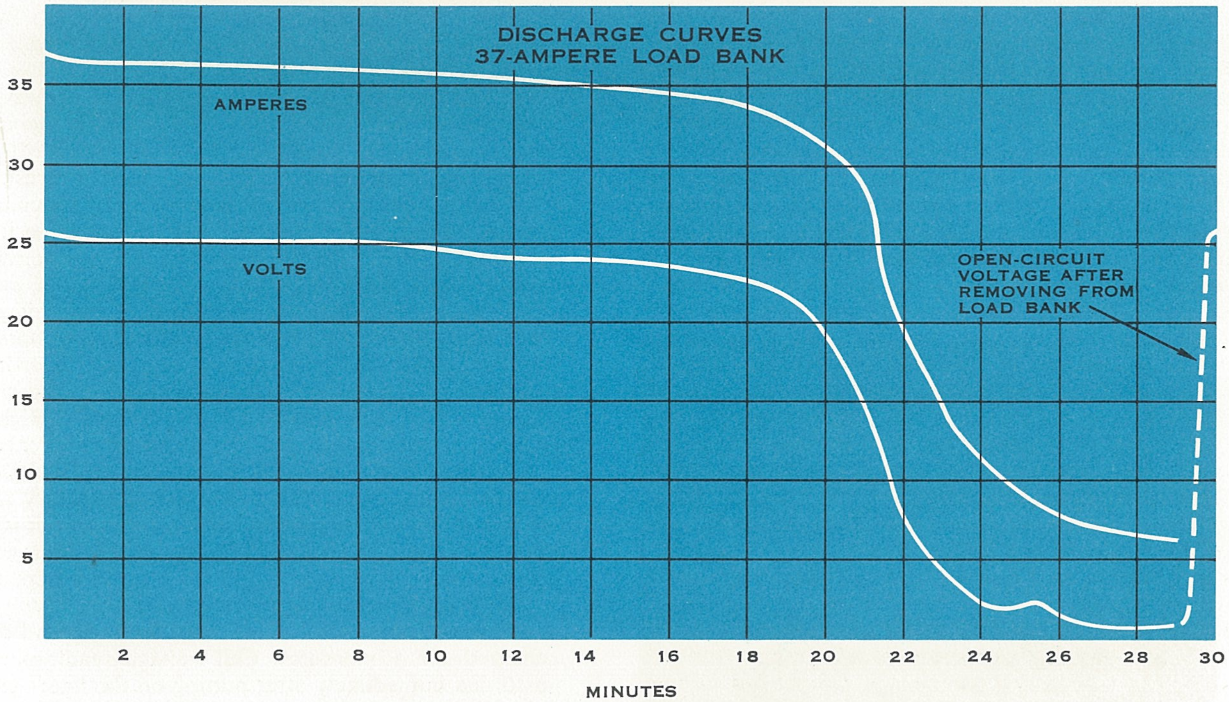
The battery control switch and an ammeter are on the upper portion of the flight engineer's panel. The switch has three positions: OFF, EMER, and NORMAL. EMER position isolates the DC emergency bus and connects it to the battery. In NORMAL, the battery is on the T-R charging circuit.

The flight engineer can, to some extent, monitor the state of charge of the battery by observation of battery voltage and the ammeter. In an airplane in ordinary daily service, when the battery has not been used during a stop, actuating the switch to NORMAL with electric power on will cause the ammeter to show a charge of perhaps 10 amperes for a few seconds. The needle should quickly go down to ½ to 1 ampere and remain there. If the battery has been in use, the bench charge curves herein may be useful for comparison to show the normal pattern.

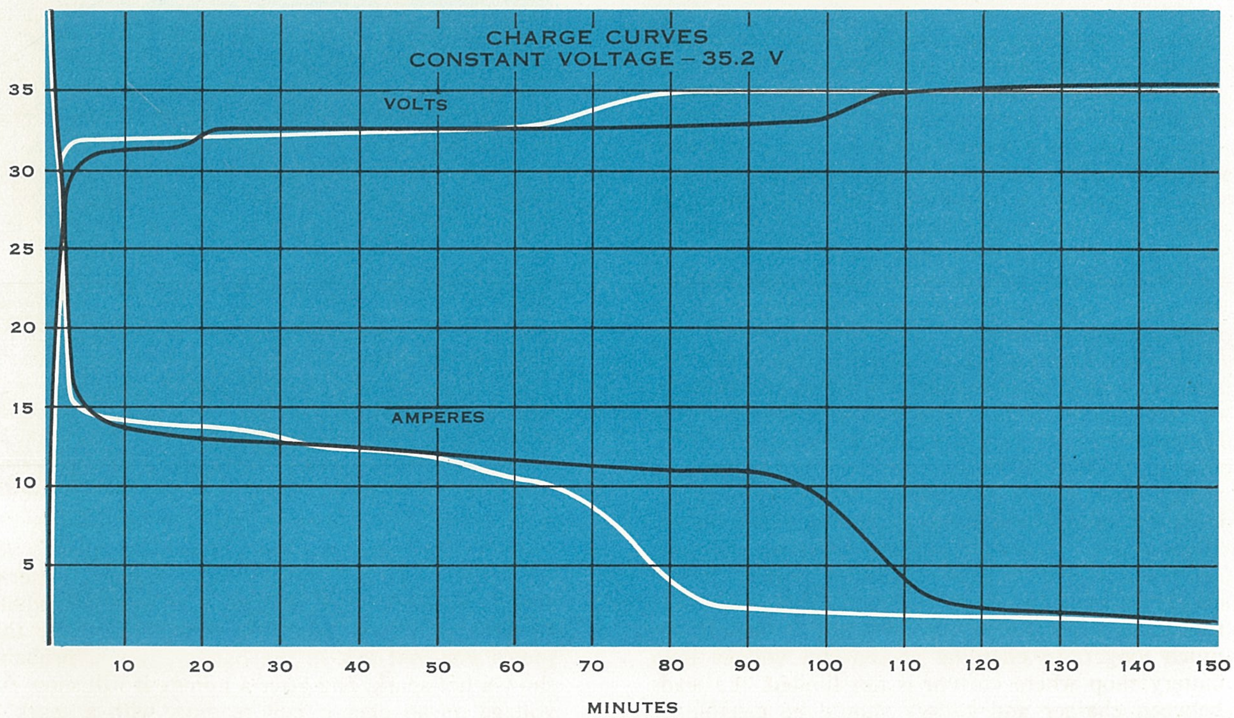
In ordinary service, there should be little or no "gassing," or hydrolysis of the water into its constituent hydrogen and oxygen. The nickel cadmium cell does not gas during discharge, and the cell is sealed to prevent loss of fluid even if inverted. In the later stages of charging, some gassing will occur. The rubber seals in the seal cap will relieve internal pressure at 6 to 8 psi. The amount of hydrogen that would be released in the airplane electrical compartment is small and is vented overboard by the air conditioning system in normal electrical compartment ventilation.

Overfilling or high-voltage bench charging may cause some bubbling over of electrolyte, leaving a visible deposit of KOH crystals. Over a period of time, the KOH may darken terminal fittings, although cadmium-coated parts and stainless steel are not ordinarily subject to corrosion from this cause. However, potassium hydroxide is about as caustic as kitchen lye and should be treated with the same respect. It is particularly corrosive to aluminum. In the airplane, any fluid that escapes from the cells would be contained in the stainless steel case.

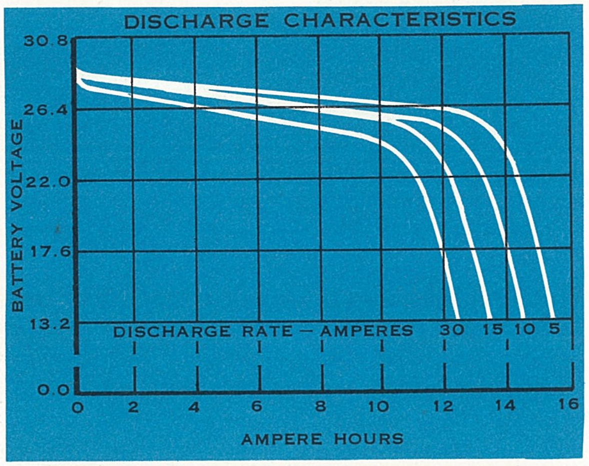
As a battery discharges, the electrolyte is absorbed into the plates. At complete discharge, electrolyte level may be down as far as an inch below the top of



Curves on this page, made in Convair battery shop, are typical. Battery above was in good condition and had been in storage, charged, for 27 days. After 17 minutes on the load bank, it still delivered 34 amperes at 23 volts. Note subsequent sharp drop, and rapid "come-back" in open-circuit voltage, even after almost complete discharge. White lines below are this battery's recharging curves. Black lines are curves of a battery charged during conditioning charge-discharge cycling. Battery had been short-circuited for 24 hours before recharging.



the plates. Since the plates are wet by capillary action, charging at normal rates with electrolyte at this low level will not damage them. Electrolyte level should be checked only after a couple of hours have elapsed since being on charge. The electrolyte should then be above the horizontal baffle over the plates. It requires approximately one-quarter inch of fluid above the baffle to float a hydrometer bulb. Hydrometer reading should be between 1250 and 1300; less than 1250 indicates the solution is too thin for adequate battery operation.



If it is necessary to add distilled water, a hydrometer reading at the time will be useless. A KOH solution is much less miscible than a sulfuric acid solution in lead batteries. It will require four or five charge-discharge cycles before the solution is mixed enough to obtain a good specific gravity reading.

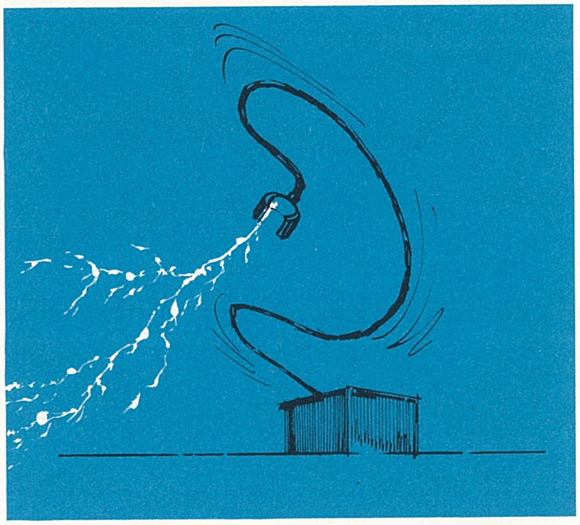
Nickel-cadmium batteries do require a certain amount of maintenance other than checking fluid level. A characteristic of the battery is a propensity for developing, over a period of time, a cell imbalance, which may or may not indicate deterioration but which lowers the battery voltage and ampere-hour capacity. Usually, it requires a complete bench check to find defective or unbalanced cells and determine if their capacity can be restored. The battery should be removed for such a check every three or four months, completely discharged, recharged at a high rate, and rechecked for capacity.

A safe discharge method, requiring no special attention, is to discharge under a 10-ampere load until the voltage is near zero, and then to short-circuit the battery terminals for at least three or four hours. Charging can be either at constant current or constant voltage. The Sonotone recommendation for constant-current charge is at 4 amperes for 4½ hours, or at 3 amperes for 6 hours. Charging from the airplane system, or directly from a ground power unit or charger, will bring the battery up within minutes to full voltage, but full capacity will not be reached for much longer. In charging at constant voltage in a battery shop where current is not limited, the leads between charger and battery should be capable of carrying 100 amperes.

Every battery maintenance shop develops its own methods, and some operators by now have had considerable experience with nickel-cadmium batteries, since they are found in many jet aircraft. However, the "880" battery is tailored to particular voltage and load requirements. Some information as to procedures found to be effective at Convair may be of interest.

When a battery is brought into the shop for charging after storage, for periodic check, or because it is showing signs of loss of capacity, an open-circuit voltage check will probably show 26 to 28 volts, even in a "dead" battery. Reading individual cell voltages may show low-voltage cells, but readings at this point are inconclusive evidence. After readings are recorded, the battery is put on a constant-voltage charger at a potential of 35.2 volts (1.60 volts per cell). Higher voltages, it has been found, are likely to cause excessive gassing and loss of electrolyte. When charging current drops to one ampere or less, the battery will be left on the line two hours longer, to be sure it is at full capacity. After fluid level is checked, a new battery is assumed to be ready for service; others are additionally checked as follows:

The battery is put on a 37-amp load bank and discharged for 17 minutes. Cell voltage readings are recorded immediately after putting on the line; again after 8 minutes and after 17 minutes. At this point, on-load voltage should be 22 volts minimum. Within two or three minutes, a "break point" is reached, and voltage and current drop sharply; the voltmeter needle will go down at the rate of 5 or 10 volts per minute. Five minutes more will see voltage and current both near zero, and the battery terminals can safely be short-circuited.



A caution note may be advisable here: *do the short-circuiting quickly*. Nickel-cadmium batteries "come back" with remarkable, almost incredible, rapidity. Ten seconds after coming off a line that shows one volt left in the battery, it will probably show a hot spark, and after a minute it will show full voltage on an open-circuit reading, with a spark to match.

After being on short-circuit overnight, or for four hours at least, the battery is put back on the charger. Initial input current is quite high — 75 amperes or more if available; sometimes, to protect instrumentation, the battery is charged on a 12-volt line for a few minutes to avoid heavy current surge. Charging current falls rapidly (see curves) and from five minutes on will usually be under 15 amperes. Again, after charging amperage levels off at one ampere or less, the battery will be left on an additional two hours. There is evidence that this has appreciable effect on ampere-hour capacity. Cell voltages are recorded while on the line after a half hour, hourly thereafter.

Immediately after coming off the line, battery potential will read 35 or 36 volts. This will drop overnight to approximately 29 volts, and to 27 to 27.5 volts after a week.

Defective or unbalanced cells will show up in the voltage readings during discharge and charge. Individual cells are easily replaced; the connector strips can be taken off by removing two nuts, and the cell lifted out of the case.

It has been found that low-voltage cells usually respond to charge-discharge cycling. If several cells in a battery show imbalance, it may be easier to put the whole battery through more than one complete charge/discharge cycle. The cells can be removed and handled separately, or in sets of four or five with a 6-volt charger.

Following are some precautions to observe in handling nickel-cadmium batteries:

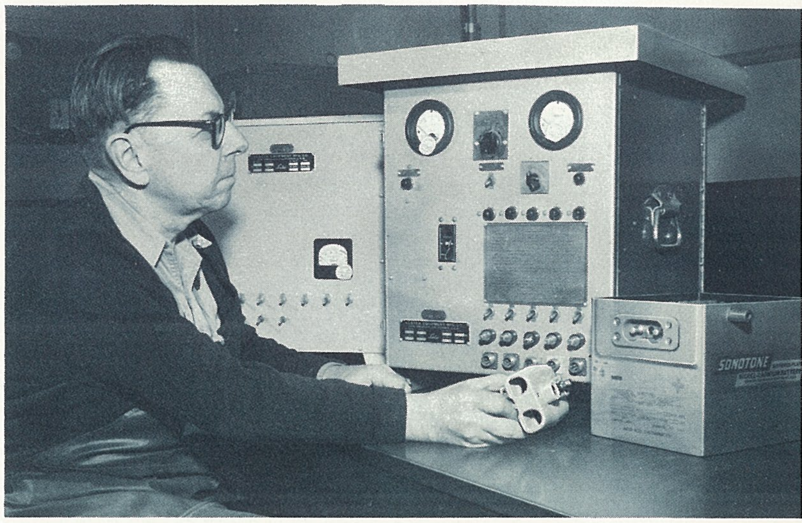
1. Do not short-circuit a charged battery, or even one cell. The internal resistance is low, the current available is very high. If a connector nut is dropped across two terminal strips, it may be red hot before it can be picked up. A single cell yields a very hot spark; a short across the main battery terminals will burn them badly. Be careful in removing the cover, and in using tools. Do not use battery clips at any time.

2. Keep nickel-cadmium facilities entirely separate from lead-acid, in different areas and with a different set of tools. Acid contamination will destroy the battery. Distilled water source, hydrometers, syringes, and all tools should be kept separate.

3. If electrolyte is spilled on the skin, rinse off immediately. Boric acid solution, vinegar, or 5% acetic acid solutions are neutralizers for KOH. Dried crystals on the battery or around the area can be washed off or loosened with a natural bristle brush and blown off with an air hose.

4. Keep cell caps on tight, even during charging. Air, containing CO_2, contaminates the electrolyte. What happens is that the carbon dioxide in the air readily combines with potassium hydroxide to make a potassium carbonate solution. In fact, the crystals noted in item 3 are likely to be potassium carbonate, a much more harmless substance than KOH.

5. In bench charging, particularly in later stages with high potential, a hydrogen-oxygen mixture may be present over the battery. Be extra careful to prevent sparking and to keep any source of fire away from the battery top.



At left of the battery is a typical constant-voltage charger, and a discharge load bank. The airplane battery connector is useful for handling heavy current in charging and discharging.

Shop necessities are hydrometer and syringe; nylon cap wrench; voltmeter; record of voltage readings; and a short-circuiting device, like that in center foreground, to protect terminals.

6. The plastic cells must always be packed in the case when charging. If separate cells are being charged, they must be boxed so that internal pressure will not distend the cell walls.

7. Although less electrolysis of water occurs in nickel-cadmium batteries than in lead-acid batteries, electrolyte level should be checked after bench charging. Be sure that the battery is well charged before adding water, and never fill the cells more than ¼ inch above the baffle. If electrolyte is known to have been lost by spilling, it can be replaced by a KOH solution of 1320 specific gravity.

TEFLON RINGS
storing and handling

TEFLON IS USED in many applications throughout Convair jet airliners because of its low coefficient of friction, exceptional resistance to most chemicals, and its high dielectric strength.

In the aircraft fluid systems, it is used principally for backup rings, seals, and linings.

No shelf life limits have been established for Teflon because, normally, it does not deteriorate with age. Certain types of Teflon seals have been known, however, to change dimension or become distorted after a period of storage.

If properly stored, Teflon rings will not change dimension or become distorted. A smooth tube or bar with well smoothed ends, which provides a close hole size fit for the rings, provides an excellent storage tool. After the rings are placed on the tube, a tight fitting "O" ring with an outside diameter larger than that of the rings, is slipped on each end and "snugged" against the rings. This protects the ends, holds the rings in shape, and lifts them sufficiently so that they do not bear on the storage shelf.

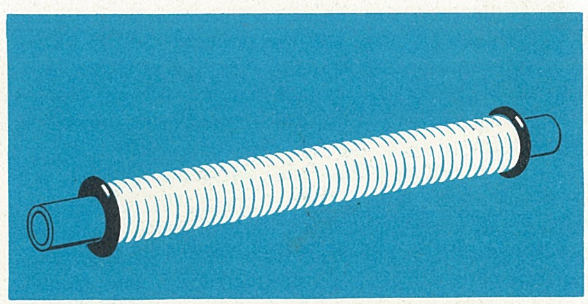
The "O" rings should always be pressed back firmly after any Teflon rings are removed. Only Teflon rings of the same size or type should be placed on the same tool.

If Teflon rings have become distorted through improper storage practices, they may often be reshaped by clamping them on a constant diameter mandrel and placing in an oven for approximately 10 minutes at 350±5°F. On removal from the oven they should be quenched in water, then stored at room temperature for 48 hours prior to use.

Dimensional stability of split or spiral backup rings can be checked by measuring and recording the dimensions of a sample ring. The circumference affords the best check. The rings to be checked are slipped onto a bar of sufficient diameter so that the circumference gap between the two ends may be measured accurately. Then, the rings are heated in an oven at 350±5°F for two hours, and allowed to cool to room temperature. The gap is again measured and compared with the original measurement. If there is more than 3% change (mean of inner and outer ring circumference), the Teflon is unstable and the part should be removed from stock.

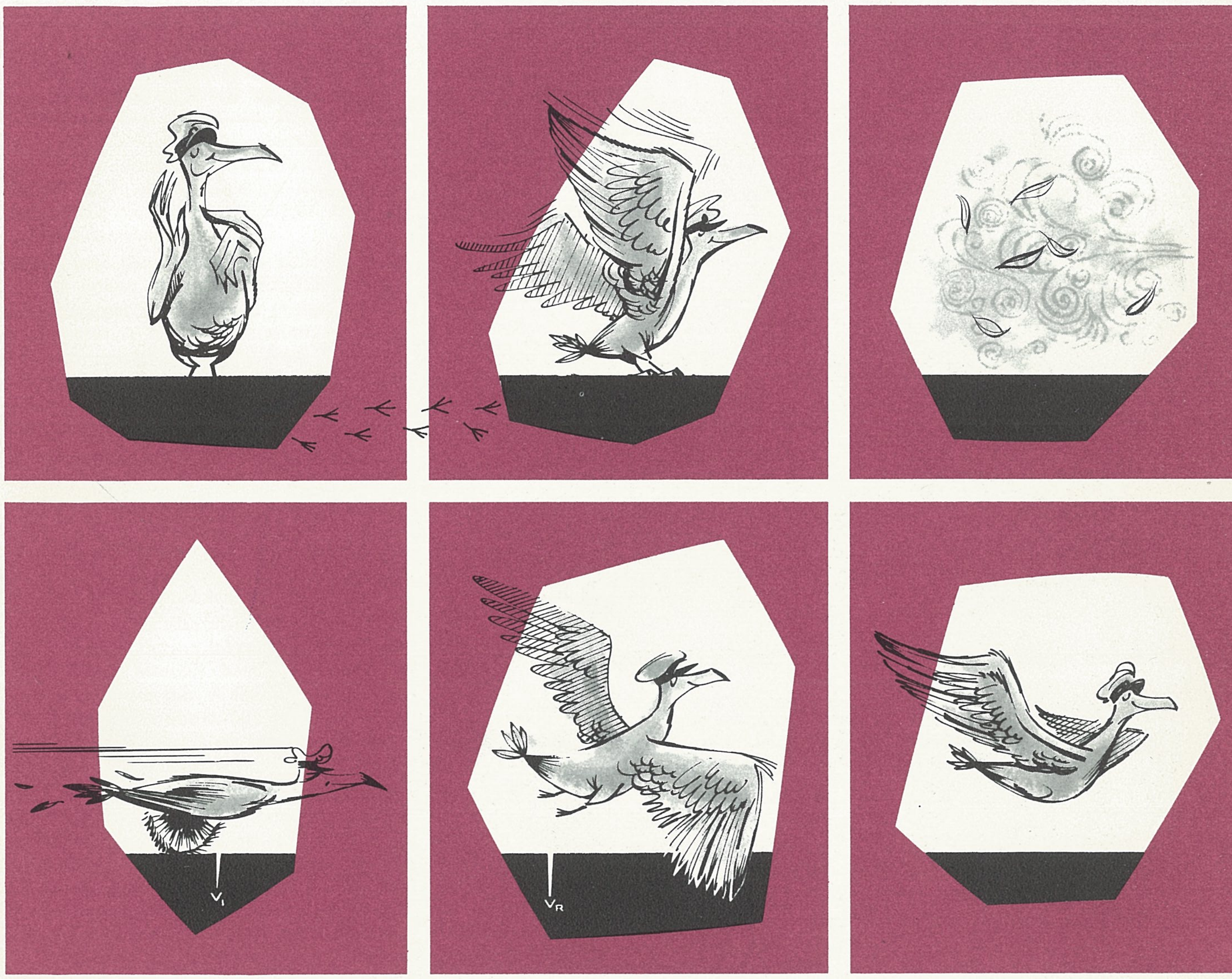
Inspection of backup rings should include a check that surfaces are free from irregularities, that edges are clean-cut and sharp, and that scarf cuts are parallel. In checking Teflon spiral backup rings, the coils should not separate more than ¼ inch when unrestrained.

Teflon should not be heated above 400°F because harmful fluorine gas is emitted when its temperature is raised to the point of vaporization.

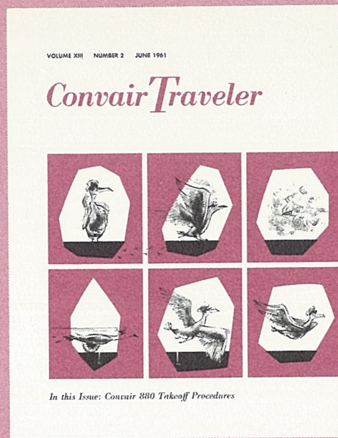


VOLUME XIII NUMBER 2 JUNE 1961

Convair Traveler



In this Issue: Convair 880 Takeoff Procedures



OUR COVER

These studies, recorded by Willis Goldsmith through magic-eye techniques, mark stages in takeoff of a very fast bird. He even beats the '880" getting airborne. The "880" will pass him in a minute; the "880" passes almost everything at cruise.

Convair Traveler

VOLUME XIII **NUMBER 2** **JUNE 1961**

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IN THIS ISSUE

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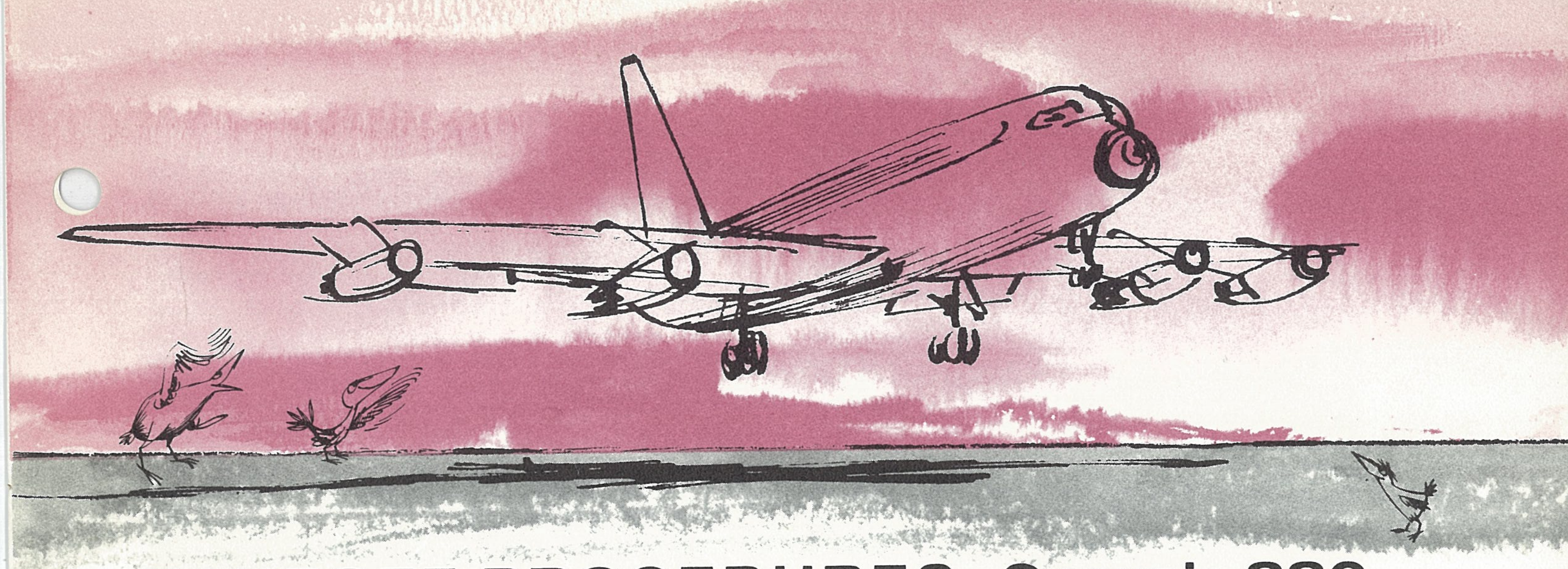


TAKEOFF PROCEDURES - Convair 880

LET US FOLLOW—with some occasional time out for comment—a typical procedure for takeoff in a Convair 880, omitting radio communications and other matters dictated by company practice that preoccupy pilots during actual operations. It may be taken for granted that V_1, V_R, and V_2, have been determined and are well in mind; that flaps are at 20° and stabilizer trim 2° to 7° aircraft nose up, depending on CG; and that all the paperwork, checklists, and flight plans have been completed.

Aligned with the runway, the pilot sets brakes, advances the power levers to TAKEOFF, and checks engine indicators: takeoff rpm (usually 103%), exhaust temperature 625°C maximum, engine pressure ratio within chart values, fuel flow 7,500 to 10,000 pph, depending on density altitude. We might stop him here, before he releases the brakes, for some cautions and comments.

Engines should be run up with brakes on. Applying power gradually with brakes off — a running takeoff — will result in a very slight increase in takeoff distance above that given in Flight Manual charts. Nose wheel steering should not be started until the airplane is rolling... the dual wheels are on the same axle and will scrub if turned while stationary.

The 625° EGT is maximum at brake release, but it may be exceeded during takeoff run in transient conditions. A Flight Manual chart gives maximum short-term allowances for this. A flight need not be aborted if EGT goes briefly above 625°, unless the pilot has reason to believe, based on chart information, that there is something wrong that requires correction.

There are no Flight Manual notices about adding runway length when anti-ice or rainclearing systems are activated. The reason is that below 50°F, an allowance has been made for the effects of bleed air on power while using anti-icing systems. This power loss is included in the field lengths computed in the manual. Rainclearing should not be turned on until takeoff roll has started; if the air heats the windshields before the airplane begins to move, the overheat protective circuits might cut off rainclearing during the takeoff.

When the pilot first releases brakes, acceleration is greatest, and it decreases gradually during takeoff roll. The pilot will have one hand on the nose steering wheel and the other on the power levers. The copilot besides monitoring airspeed and the instruments, holds forward pressure on the control column. Stabilizer trim tends to lighten the nose; some elevator-down input helps stabilize ground roll, and aids directional control in the event of loss of an engine. Also, any excess nose-up attitude adds to aerodynamic drag. In general, if there is any doubt about the exact amount of stabilizer trim setting for the particular CG, it is better to trim for a forward CG and trim as required when airborne. The elevator being about half as effective as the stabilizer per degree of deflection, 2° of elevator will offset 1° of stabilizer trim.

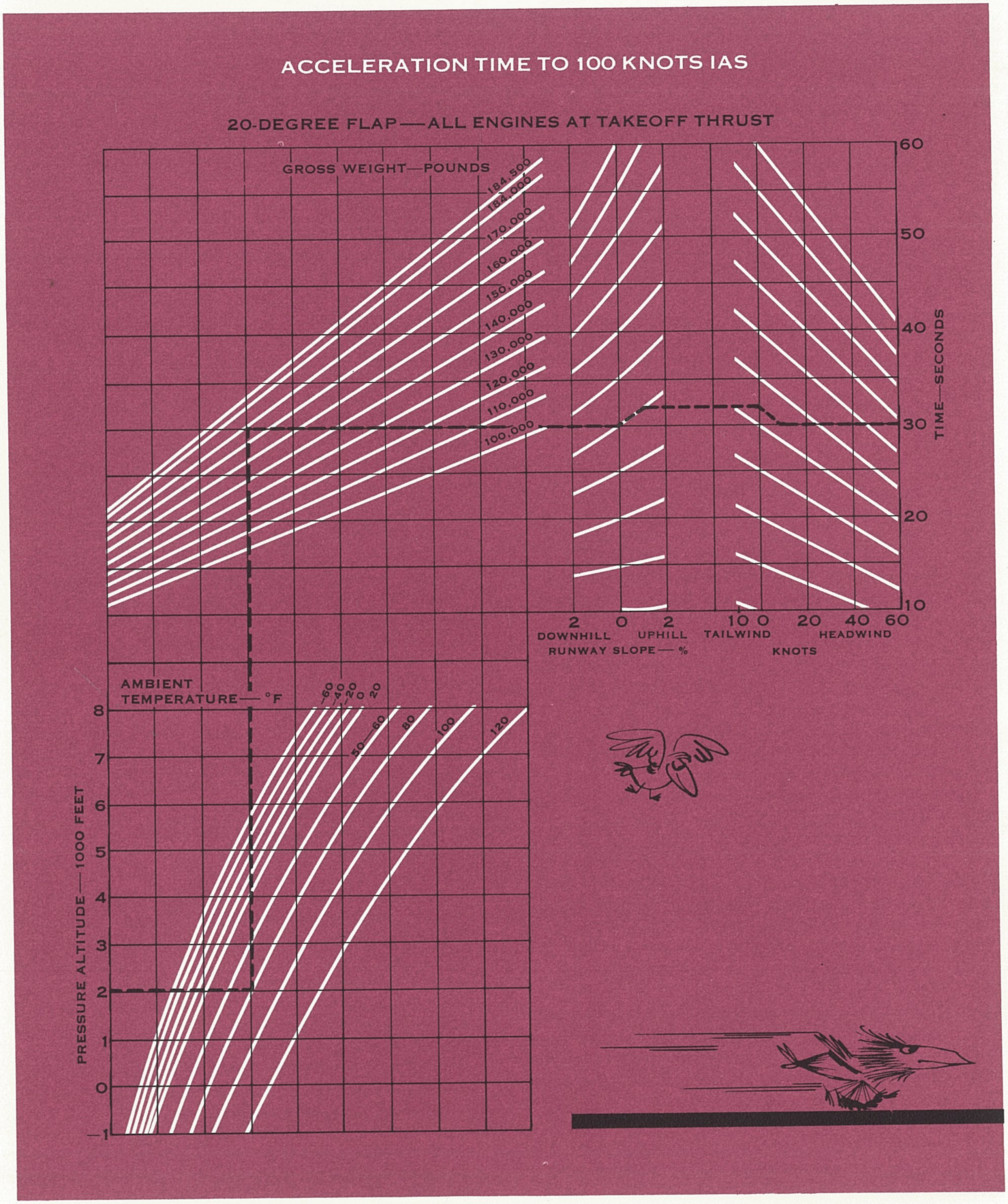
If there is a crosswind, lateral control input should be kept to a minimum. Spoiler action increases the tendency to weathercock. In the older aircraft, aileron action helped to counteract weathercocking, since drag is slightly greater on the down-aileron side. However, the upwind spoiler is the one that would be extended in keeping the upwind wing down, increasing the weathercocking tendency and requiring increased opposite rudder. The net effect, when large lateral control inputs are used to attempt to keep wings level, is an unusually aggravated crossed-control condition. Control input should be eased off at rotation so that the airplane will not bank too sharply on liftoff.

Rudder control becomes effective at 70 to 80 kts, and at this speed the pilot will release the nose steering wheel to man the control column.

The first official speed objective is V_1. There may, however, arise some question in the pilot's mind as to whether he is going to reach V_1 on schedule. This is, as of the present, an "unofficial" concern. CAM 4b requires that the Flight Manual furnish means to determine minimum runway length and V_1, but it does not take account of the possibility that acceleration may be slowed by dragging brakes, rain puddles, or slush. (It should be noted, however, that field lengths are based on power resulting from minimum acceptable EPR values shown in the Flight Manual.)

It is evident that a third element is missing – some measure of acceleration. The FAA-approved Flight Manuals do not usually give that information, but it is available.

Takeoff acceleration can be measured either in distance or in time. Time is easier to monitor; few civil runways are clearly marked, in distance, and the pilots are watching instrument panels pretty closely anyway during takeoff roll. The accompanying chart gives acceleration time to 100 kts IAS. It was prepared by Convair from computer-processed flight test data and checked by Convair pilots. Other charts have been prepared showing additional runway needed when water or slush is present. These curves make use of data compiled from slush tests by NASA and applied to "880" takeoff thrust and drag data.



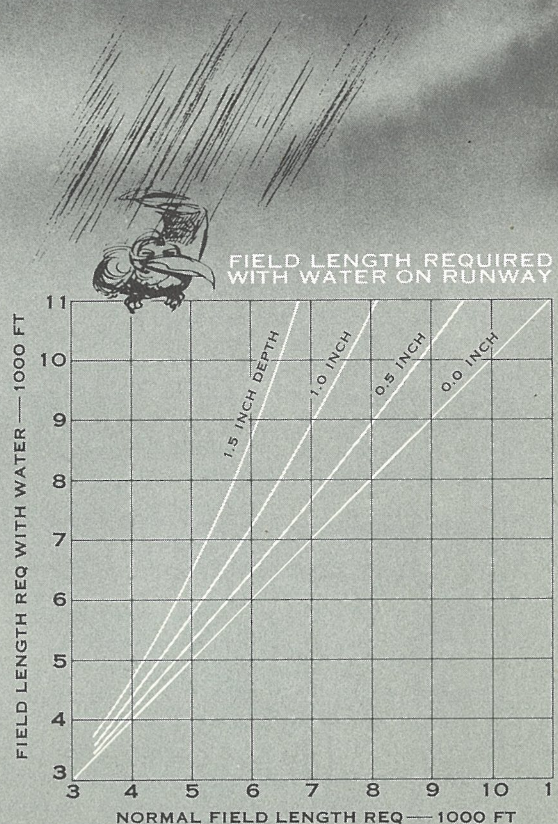
Assuming that V_1 is attained without difficulty, the pilot, at V_R, pulls back on the control column — firmly *but smoothly*. This often has to be emphasized to pilots accustomed to less responsive propeller aircraft. Too fast a rotation may result in a touch of stall buffet onset. If the airplane is rotated too soon or too rapidly, the pilot should be prepared to take a little extra care to maintain precise lateral control at liftoff.

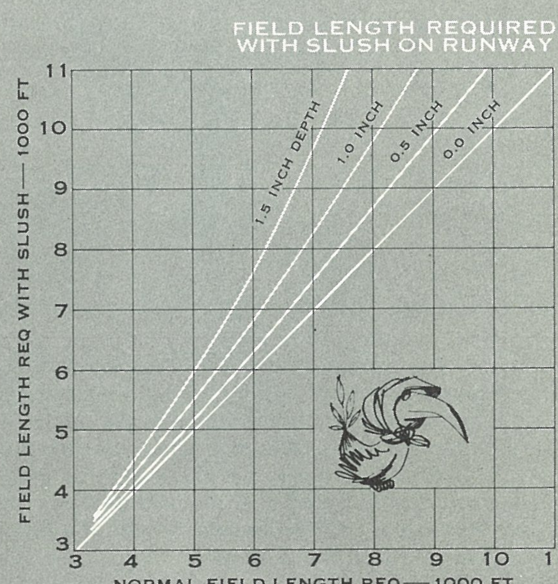
The amount of rotation is from 7° to 10°, depending on gross weight. There being no protractors provided along the runway, the pilot's best assessment of his angle with the horizon is obtained from the artificial horizon indicator. The Sperry indicator has a mark at 10°; the Bendix indication is approximately the same displacement of the horizon line, 1/4 to 5/16 inch. Pilots sometimes express doubt whether the reading will be accurate on takeoff, since the gyro erection mechanism, during acceleration, tries to align gyro vertical with the false gravity created by acceleration. However, gyro erection is at the rate of only 2° per minute, and even when fully operative has an almost imperceptible effect on horizon indication during takeoff. Convair pilots report that at liftoff the aberration is less than the width of the horizon line. Also, the Sperry system has an acceleration switch that cuts off gyro erection during the first several minutes of takeoff and climb.

Airspeed indicators show a minor discrepancy during liftoff that probably should be identified and explained. The Flight Manual charts for correcting indicated-to-calibrated airspeed show that, during ground roll, knots must be added to IAS to obtain CAS. Airborne (out of ground effect) at low speeds, knots must be subtracted. On the airspeed indicator, the ground-to-airborne transition through rotation and initial climbout is marked rather abruptly; as the airplane leaves the ground, the needle moves rapidly up four or five knots, sometimes more. The discrepancy is less significant than it might appear. During this second or two, the pilot is not specifically concerned with speed. The chart by which he determined V_R gave him IAS groundborne; the chart for V_2 gave him IAS airborne. His indicator, therefore, gave him a true reading to obtain the correct V_R in terms of CAS. A few seconds after liftoff, when he has time to be interested in airspeed again, the indicator will give the proper reading relative to calibrated V_2 airspeed.

Typically, the "880" lifts off about halfway between V_R and V_2. For normal elevator inputs with all engines operating, the speed at 35 ft will be about 10 kts faster than V_2. Initial climb may be made at $V_2 + 10$ to 20 kts, the higher speed being used for lighter weights. Flap retraction rate is limited to 10° retraction for each 10-kt increment above V_2. Usually, the pilot waits until $V_2 + 20$ (which he should attain by the time he reaches 400 ft) to retract flaps. He then drops the nose to an attitude of 4° to 5°, pulls the power levers back to maximum continuous climb (97%), and lets the airplane accelerate to the desired climb speed, as indicated by departure control.

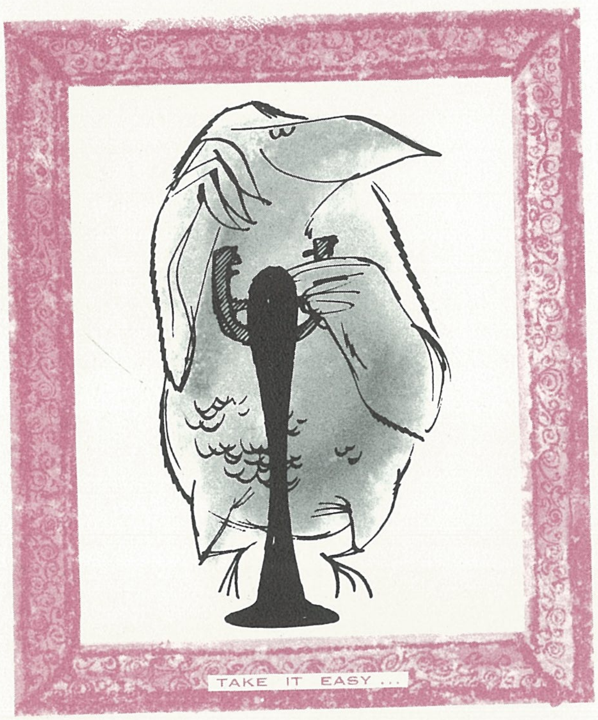
When the flight path lies over a noise-sensitive area, the climbout may be made a little steeper to obtain altitude quickly, or climb angle may be lowered to



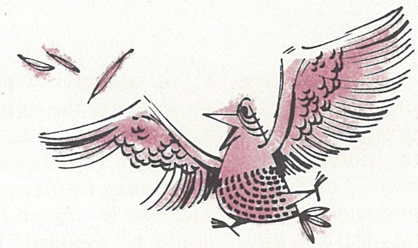


reduce power requirement and thereby reduce engine noise. Recommended noise abatement procedure is to climb initially with takeoff power and flap setting at $V_2 + 10$ kts, regardless of gross weight. This will result in a climb attitude of 11° to 12° with a heavily loaded airplane (over 160,000 lb), or 16° to 17° with a lighter one (under 140,000 lb). It is perhaps preferable to limit climb attitude to 15° and accept a higher speed if necessary. At 1000 ft altitude, or whenever a noise-sensitive area is reached, the nose is lowered and power reduced to just enough to maintain a rate of climb of 500 ft/min. When 2000 ft is reached or whenever the noise-sensitive area is cleared, climb power is reapplied, flaps are retracted, and normal climb established.

Once on its way, the "880" pilot can make use of a powerful aid in manual flying — the yaw damper. Use of the yaw damper, however, is prohibited during takeoff and landing; under some conditions, including engine-out operation, the pilot would have to fight the yaw damper rudder input. During rotation and initial climb, when the most precise control is required, the pilot must do the flying. This is a matter of skill level and cannot be learned elsewhere than at the controls of an "880", but the importance of precision flying must be constantly in mind.



The caution that is always given to pilots checking out in an "880" — or in any of the new jet transports, for that matter — is similar to the advice they probably got from their instructors on their first student flight: "Take it easy and don't fight the stick." The big jets have quite a bit of moment in responding to controls; they can't be yanked around. If a flier has put in some years flying propeller aircraft, he often has to develop a little extra finesse in handling the swept-wing transports.



Takeoff Emergencies

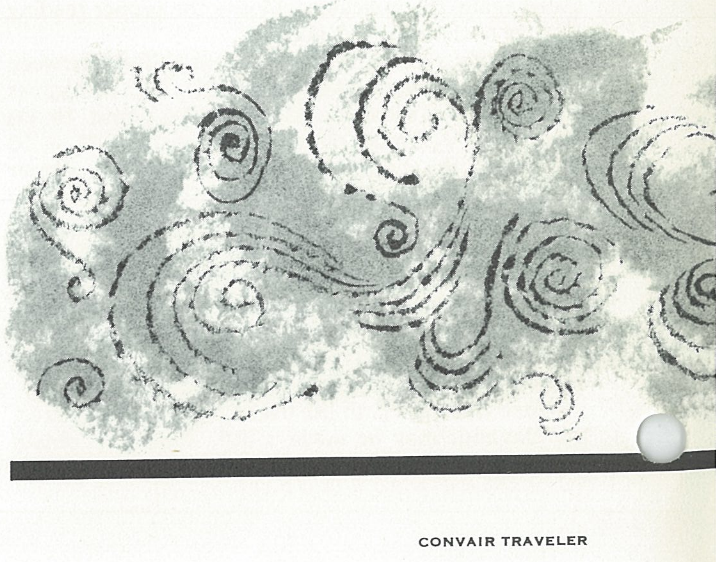
FOR TRANSPORT TYPE AIRCRAFT, the crucial takeoff emergency is the sudden loss of power from one engine at V_1 or afterward. It is the anticipation of this emergency that establishes minimum control speeds and runway lengths, and maximum gross weights permissible.

It may be remarked, without elaborating on reasons therefor, that an engine failure on takeoff is much rarer in jet transport operations than with reciprocating engines. If it should happen at V_1, the pilot has a quick decision to make. Of the two possibilities — aborting or continuing the takeoff with an engine shut down — the first usually seems to concern the new pilot of an "880" more than the second. Having experienced the feeling of the thrust, he seems to worry less about having enough power to fly on three engines than about bringing all that weight to a stop.

Just how much the feeling is justified is not a question to which a hard-and-fast answer can be given. There are too many circumstances and variables involved. Even with all factors equal, one pilot's decision may not be another's. All that can be done herein is to point out some principal considerations.

On the one side, it may be noted that the minimum takeoff field lengths in the Flight Manual were determined by rigorous flight test; that they are based on maximum braking, with a two-second allowance for power reduction, without reverse thrust; and that reverse thrust is still available from the two balanced engines remaining. Many takeoffs are not field-length-limited; therefore there is often extra stopping distance.

On the other hand, there is some statistical support for continuing the takeoff on three engines; the Air



Force estimates that three-quarters of its multi-engine losses from engine failure on takeoff have occurred in attempts to abort. Another item is the fact that in such an emergency the pilot usually knows that he has three good engines operating. He can't be equally sure that all ten—or eight—brakes are operating properly, because taxi check offers no chance to test under heavy loading. When V_1 is field-length-limited, a wet surface, a bad brake, or a few seconds indecision or delay in beginning to decelerate might make it impossible not to overrun.

One intangible but very definite factor is the pilot attitude of mind. Once V_1 has been called out, both pilots are all set to start flying. There is an inevitable mental inertia to overcome in reversing procedures and promptly devoting all energies to stopping rather than getting off the ground.

Generally speaking, Convair pilots agree that when V_1 is limited by field length, they would be inclined to favor a three-engine takeoff over an abort. When excess runway is available, they might abort. But other circumstances could influence either decision — a wet runway surface, or indications of malfunction involving more than just loss of thrust from one engine.

If the pilot elects to continue the takeoff, the procedure is much like that in any multi-engine airplane. The pilot will probably use hard rudder to check the dynamic swing, slacking off as necessary to maintain the desired direction. Rotation is at the same rate. On liftoff, the wing with the dead engine will be raised... a 5° bank was used in certification. The climb should be at V_2 to $V_2 + 10$ kts — never less than V_2.

It was noted earlier that today's swept-wing jets have relatively more lateral stability at the expense of directional stability. Diminished directional stability, greater thrust and increased lateral sensitivity all tend to have an adverse effect on ease of control in engine-out takeoff and flight. The greater thrust of each engine means more asymmetric force when one engine is lost. Also, outboard engines are farther out on the wing.

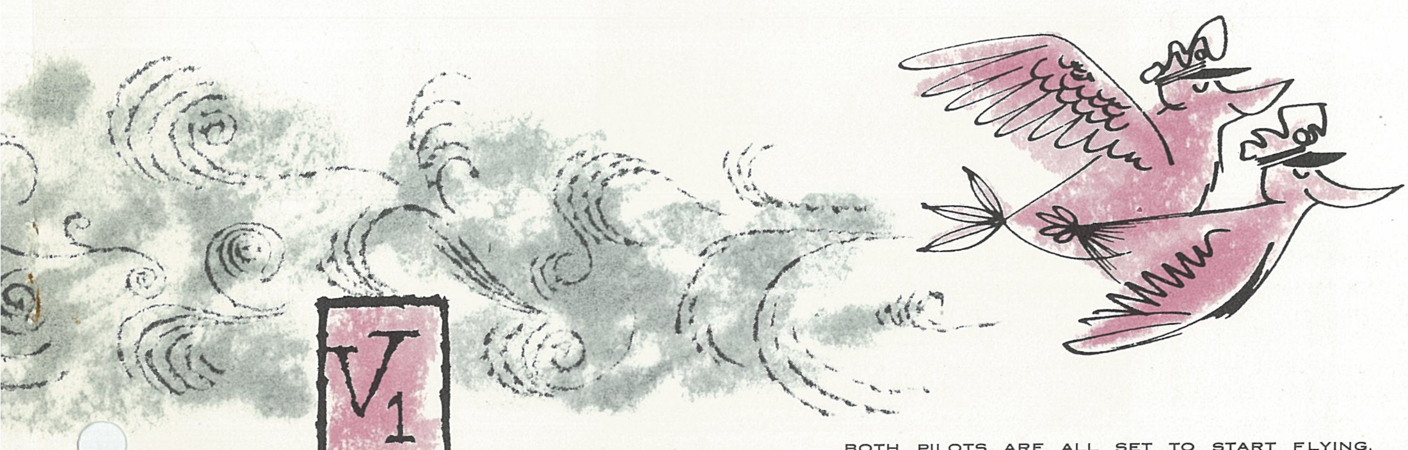
With an outboard engine dead, a good deal of pedal pressure is required on liftoff to hold a straight course. At the lighter weights, V_{LOF} is near V_{MCA}, and at V_{MCA}, with a 5° bank, full rudder deflection is required — that being how V_{MCA} was established to begin with. V_R and V_2 are both required to be greater than V_{MCA}, so the pilot will have adequate directional control power, but between V_R and V_2 the margin is narrower than in the typical piston engine transport.

This is not to imply that a three-engine takeoff is a marginal operation; such takeoffs are being made all the time in "880" flight training. By FAA requirements, engine-out takeoffs must be possible without requiring any unusual degree of piloting skill. But it is more important than ever to "drive carefully," to make changes in flight attitude cautiously, not to chase airspeed, and to allow sufficient time for corrections in attitude and speed to stabilize before making further pitch corrections. Changes in G-loads, and added drag due to excess surface deflection, cut down climb performance.

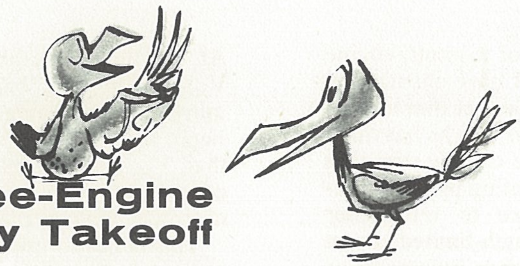
After sufficient altitude has been reached, speed can be increased until the airplane can be trimmed for straight and level flight. Until this is possible, the engine-out wing should not be lifted more than 5°. Rudder, not slip, must be used to maintain direction. Excessive slip, especially at altitudes too low for diving recovery, is dangerous. This is a characteristic of swept-wing and delta-wing aircraft.

In the "880," the critical yaw angle is slightly above 15°, depending on airspeed. The pilot has no instruments for gaging yaw angle. He should know, however, that at approximately 15° yaw angle, the rudder tab is blanketed so that the rudder returns toward streamline; at 17° to 18° yaw, directional control is lost and the airplane turns into the dead engine, yawing enough for the rolling moment to offset any lateral control.

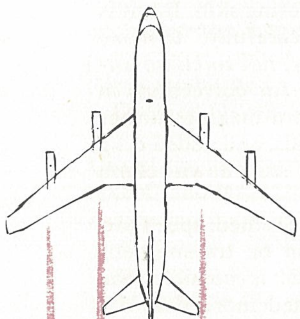
Holding bank angle to a maximum 5° results in only about 3° of yaw, maintaining a considerable margin away from such a condition. The best practice is to fly always with the ball in the turn-and-slip indicator as near center as possible. It should never be more than three-quarters ball-width from center; a quarter-ball deflection is enough for engine-out climb at V_2.



... BOTH PILOTS ARE ALL SET TO START FLYING.



Three-Engine Ferry Takeoff



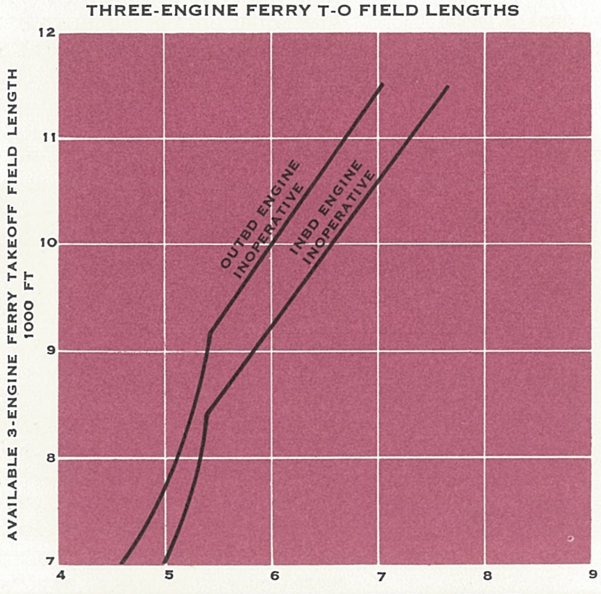
PROCEDURES ALLOWING A MINIMUM flight crew to ferry a Convair 880 jet airliner with one engine inoperative appear in the FAA-approved supplement to the Flight Manual. For such a takeoff, runway minimum length is 7,000 feet. Maximum weight is 145,000 lb without an inboard engine, and 133,500 lb without an outboard engine. This type of operation makes no provision for climb-out with an engine failure during takeoff.

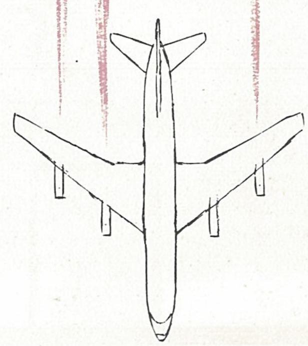
The takeoff run is subject to asymmetric thrust all the way. If the dead engine is inboard, takeoff thrust is applied to the outboard engines and only 80% thrust to the other inboard engine. Rudder trim is preset at 3° against the two-engine operating side. At 60 kts IAS, the power lever on the inboard engine is gradually advanced until full takeoff thrust is reached at 100 kts. V_R and V_2 values are as in normal takeoff, and climb after takeoff is as previously described herein.

With an outboard engine inoperative, rudder trim is 7° and the operating outboard engine is held to idle on brake release. At 60 kts, the power lever is advanced slowly until maximum power is applied at V_1. In the upper range of power settings, from 90% to 100% rpm, engine thrust increases rapidly, and power lever advances must be made slowly.

A supplemental chart in the Flight Manual relates three-engine runway requirements to the normal field-length-required chart of the manual.

THREE-ENGINE FERRY T-O FIELD LENGTHS





WATER IN JET FUELS

AVIATION TURBINE (JET) FUELS present greater moisture contamination problems than do the AVGAS (high octane) fuels. Kerosene type jet fuels have a higher affinity for water than do high octane fuels and, because of their higher specific gravity, they retain water in suspension longer. Water is dispersed throughout fuel just as water vapor is dispersed in the atmosphere, and the higher the temperature, the greater the amount of water absorbed by the fuel.

If jet fuel is saturated with water, it will hold this water in suspension as long as the equilibrium is not disturbed. Low ambient temperatures tend to intensify the accumulation of large quantities of water — either in the bottom of the tank, or as frozen particles held in suspension in the fuel.

The suspended water can become troublesome if the temperature drops sufficiently to freeze the minute water particles into ice. This ice, known as "gel," is a jelly-like combination of ice crystals and jet fuel. Fuel system filters could become clogged with this gel, and engine fuel starvation could result.

To minimize clogging, Convair jet transports are provided with fuel system filters incorporating automatic bypass valves, which operate on a pressure differential principle. The filters are provided as part of the G.E. engine. If the pressure across the filter should build up because of clogging from gel or other contaminants, the valve opens and permits the fuel to flow around the filter. Normally, gel will not clog the filter because the fuel is first directed through an air-to-fuel heat exchanger which dissolves any existing gel before it reaches the filter.

The air-to-fuel heat exchanger derives its heat from the engine's 17th stage compressor, and the amount of heat supplied to warm the fuel is automatically regulated by a sensing element, located at the fuel outlet port of the heat exchanger.

To minimize water content in jet fuels, proper handling from the storage tank to the refueling truck, and from the refueling truck to the airplane tank is necessary because fuel picks up moisture from the air and through condensation as it is transferred from one tank to another.

Suppliers of jet fuels must be careful to deliver them in a dry condition. This does not, however, eliminate the water problem. Fuel storage tanks and aircraft fuel tanks are provided with vents to allow the fuel to be drawn from the tanks and to permit the tanks to "breathe" when the fuel expands or contracts with changes in temperature. Partially-full tanks can "breathe" a considerable amount of air, and unsaturated fuel in contact with humid air will absorb water from the air. Unless dehumidified (some storage facilities include air dehumidifiers), fuel can absorb water both by direct contact and by condensation.

No hard and fast rule or number has been established for a maximum permissible water-to-fuel content for safe operation; however, it is generally accepted that 30 parts per million is a desirable optimum.

Jet fuels are either colorless or straw-colored, making it difficult to detect water after it has settled out. A cloudy fuel it not necessarily an indication of a saturated fuel. Perfectly clear fuel can contain three times the volume of water considered to be tolerable.

Several field methods for checking water content have been devised. One consists of adding a food coloring that is soluble in water, but not in fuel. Colorless fuel samples acquire a definite tint if water is present. This method was developed by one airline and is used as a regular part of their sump drain procedure.

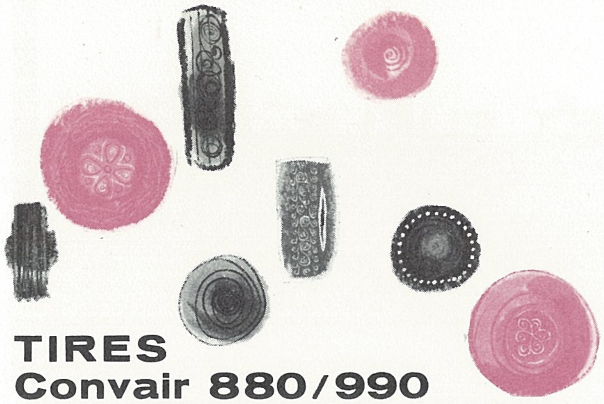
Esso Research and Engineering Company has devised a test kit, "Hydrokit," which utilizes a gray chemical powder that changes color to pink through purple, if 30 ppm or more of water is contained in a fuel sample.

A third method, developed by Shell Petroleum Company, Limited, employs a hypodermic syringe to draw a 5-milliliter fuel sample through a chemically-treated filter. If the sample changes the color of the filter from yellow to blue, the fuel contains 30 ppm or more of water.

Servicing vehicles that dispense fuel to aircraft are generally equipped with 5-micron filters and water separators to remove water to a point well below the saturation level of the fuel.

Proper operation and condition of fueling equipment is necessary to insure unsaturated fuel. In addition to testing delivered fuels for water content, good ground fuel management includes periodic draining of fuel storage tank sumps and fuel trucks, checking condition of fueling equipment, and making periodic laboratory tests of the fuel supply.

It is good practice to drain low points in the aircraft fuel system both before refueling and immediately after flight, or at least once a day. If tank sumps are not drained before refueling, the relatively warm fuel added to the tanks may be contaminated by free water in the tank, and dangerous water contamination may accrue in the fuel tanks, even though the airplane has been serviced with dry fuel exclusively.



TIRES
Convair 880/990

TIRES ON THE CONVAIR 880/990 jet airliners perform a giant task despite their relatively small size. Not much larger than the tires on an automobile, they operate at more than twice the speed of a car and carry more than 20 times the weight.

Although the tires of the aircraft are in a static condition most of the time and do not contribute to actual flight, their role is a critical one and their importance cannot be overemphasized. For a few moments relative to each flight — during taxiing, takeoff, and landing — the tires of the jet airliner determine the success or failure of the mission.

Supporting the weight of the big jet at speeds approaching 200 knots is a remarkable feat for a resilient tire reinforced with fabric and weighing approximately 100 pounds. Besides the high centrifugal forces encountered at such speeds, heat buildup from brakes and tire flexing, and impact forces of landings, combine to mete out punishment of a magnitude to which other airplane components are rarely subjected.

Aside from the damage from sharp objects encountered on runways and ramps (which accounts for most tire damage), heat is the greatest cause of tire deterioration. Heat not only weakens the rubber, but weakens the reinforcing cord structure as well. As tires are vulcanized at approximately 300°F, any tire reaching or exceeding this temperature will deteriorate rapidly. Over a period of time, tires deteriorate at lower temperatures, the length of time being inversely proportional to the amount of heat encountered.

Rubber is a poor conductor of heat, and presents a cooling problem. The flexing action of a rolling tire creates internal heat which progressively builds up within the tire at a faster rate than the heat can be dissipated. When brakes are used excessively as in long taxi rolls, frequent takeoffs and landings, and abortive takeoffs, brakes become extremely hot, and transfer additional heat through the wheels to the tires.

The "880/990" jet airliners are equipped with tubeless tires and split type wheels. Tubeless tires generate less heat than do tires with inner tubes. As a prevention against blowouts, the split wheels have blowout plugs incorporated in their rims. These fusible metal plugs are comparable to fuses and are designed to blow out at a temperature of approximately 360°F. This feature eliminates the hazard of a wheel and tire explosion that could occur without them. The tires have a margin of safety in their design that normally prolongs the explosion point to a temperature beyond the melting point of the blowout plug.

To take advantage of this margin of safety, all tires must be maintained in good condition. Since sharp objects contacting tires cause most tire damage, ramps, taxiways and runways should be swept clean of such debris, and tires should be inspected often for exterior damage. Cuts, breaks, bruises, loose tread, air blisters, chafing, and uneven or excessive wear are conditions to look for when inspecting tires.

Objects imbedded in a tire must be removed to determine the extent of the damage and to prevent the damage from growing. A blunt instrument should be used for object removal, and care must be exercised not to increase the size and depth of the opening. It is important always to protect the eyes when removing objects imbedded in rubber because the objects may eject suddenly with great force.

A tire severely damaged by bruising will be distorted by a bulge in the bruised area. A bruised tire will usually fail before an undamaged one under the same set of conditions. Bruised tires are usually caused by running over obstructions or rolling off the runway and, after such treatment, a thorough inspection of the tires should be made.

Flexing and heat will weaken a defective, abused, or cut tire to the breaking point long before a normal tire will blow out, and perhaps before the blowout plug melts. Careful inspection and maintenance of jet airliner tires will promote the safety of all concerned, and will prolong the life of the tires.

The more a tire is subjected to heat, the more it will wear. It will also be more susceptible to centrifugal force and tread separation. Skidding, scrubbing, side loads, and high-speed landings all contribute to the wear and tear of a tire.

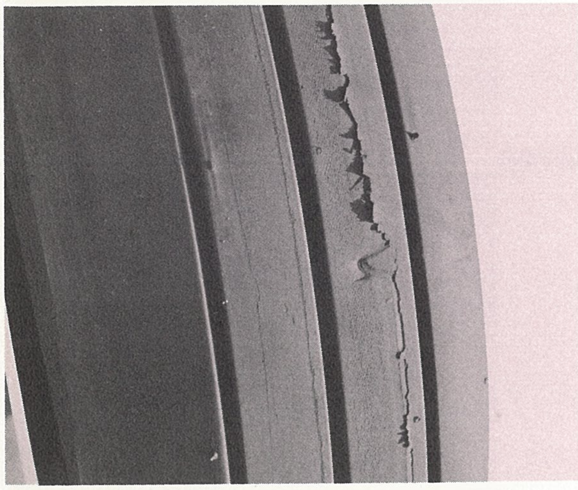
The tires installed on the Convair 880/990 jet airliners are designed to withstand the abusive treatment of normal operating conditions, but all tires subjected to excessive forms of punishment should undergo a thorough inspection before being ok'd for continued service. If there is any doubt about the serviceability of a tire, it should be replaced.

Landing more often than at one-half-hour intervals does not allow enough time for adequate cooling of brakes and tires between flights. On flights requiring frequent landings, such as during pilot training and/or accelerated flight testing, it is recommended that 1) tires be overinflated (20% over normal) to keep tire heat down to a minimum as a result of sidewall flexing and 2) the landing gear be left extended to take advantage of airstream cooling.

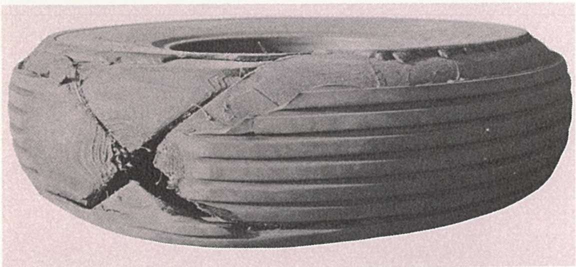
In the case of an R.T.O. (rejected takeoff), where excessive braking has been applied, a safe rule is to wait 30 to 45 minutes before approaching the tires. Then the tires should be approached from the front or rear, never from the side.

Wire cages equipped with blowers that are placed over excessively heated landing gear have been used satisfactorily by Convair to contain and cool the units. As a word of caution, an overheated wheel and tire should not be cooled rapidly (as with water or other fluid), or they may explode. Of course, if a tire is on fire, it should be quenched by the quickest means at hand. Here again, a position in line with the tires is the safest.

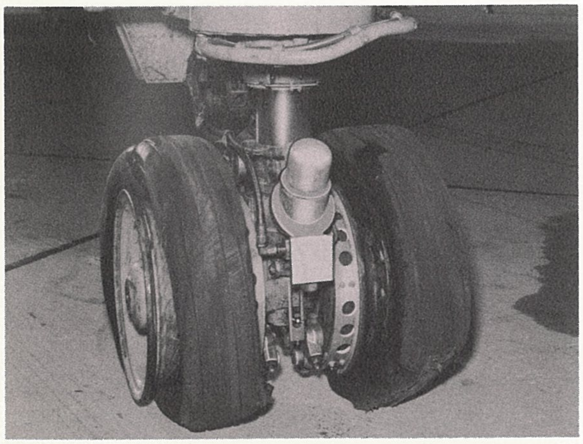
Tire showing puncture damage. This tire rejected.



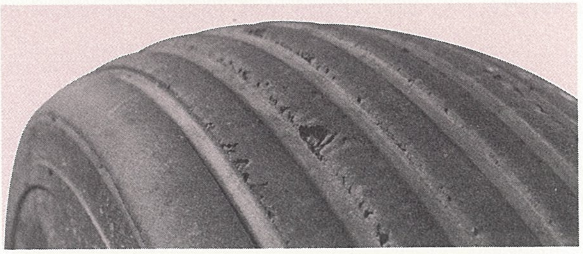
Scrubbing (sliding sideways). Tire still serviceable.



Blowout from excessive skidding during braking test.



Blowout from overheated tires weakened by skidding.



Tread chipping due to defective retread. Rejected.

Tires on jet airliners should be paired to avoid excessive twisting of the truck. The maximum circumferential difference between main gear tires on the same axle is three inches. This tolerance can be easily maintained if tires from the same manufacturer are used on the same axle. Pairing a new and a badly worn tire of the same manufacturer will not exceed this limit. Observing this limit is especially necessary on the "880" where an excessive difference in wheel diameters can result in skidding of the smaller wheel (being more lightly loaded), which in turn depletes the pressure in the pressure modulator, resulting in lower-than-optimum brake pressures and longer stopping distances. The "880M" and "990" are not affected in this manner.

It is also important that nose wheel tires be matched by manufacturer and amount of wear. Experience has shown that a circumferential difference should not exceed .56 inch, to preclude pulling the airplane to one side.

Correct tire inflation is important in the life of a tire, as both underinflation and overinflation have an undesirable effect. Underinflation subjects a tire to greater flexing which builds up more heat and also breaks down the sidewalls. Overinflation strains the tire, lowers resistance to bruising, increases skidding tendencies, and subjects the center of the tread to excessive wear. A slightly overinflated tire is less subject to damage than is an underinflated one.

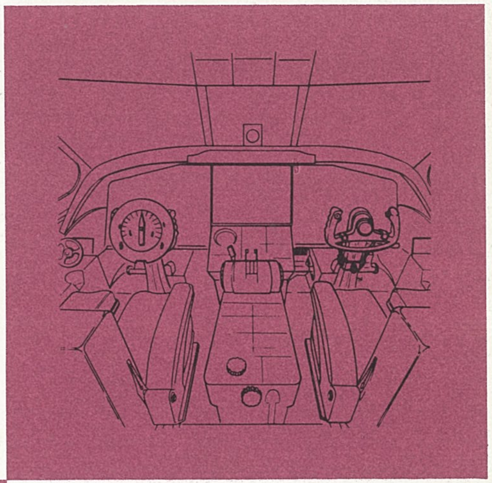
Tire pressure should not be checked while the tire is hot. Tires are designed for pressure increases that occur during normal operation. If tire pressure is adjusted to the correct reading while the tire is hot, it will become underinflated as it cools and the temperature returns to normal.

All tires, particularly tubeless types, leak a certain amount. If a tire leaks more than 5 percent in a 24-hour period it should be replaced. Because new tires have a tendency to grow a little, thereby reducing pressure, they should be rechecked 24 hours after installation. Air pressure between paired tires should not vary more than 5 pounds.

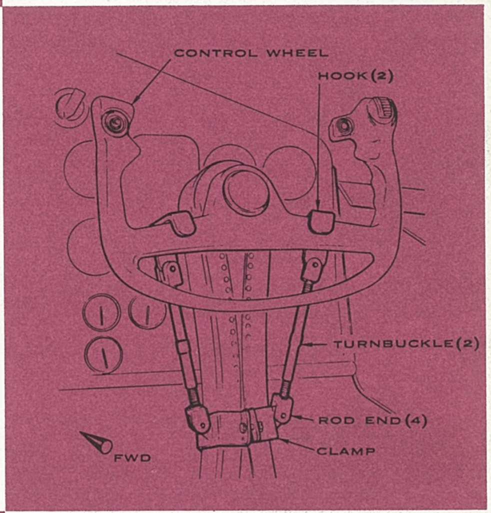
Tubeless tires may also leak as a result of wheel porosity, defect, or flange damage; or as a result of damage or incorrect fit of the O-ring that seals the two wheel halves.

Valve cores on the tires should be checked for leakage at the time the tires are checked for pressure. A small amount of water or saliva over the core opening will bubble if a leak is present. When replacing valve caps, screw down no more than finger tight. Use the latest TRA valve cores.

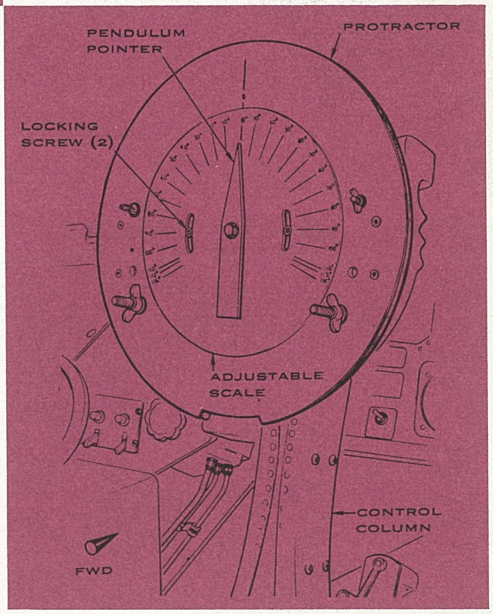
CONTROL COLUMN/AILERON CHECKING TOOLS



A TEST TOOL for rigging and checking the ailerons is used on the Convair 880 production line. This tool (22-04302) consists of two parts: a lock to hold the control wheel against movement, and a protractor to measure movement and provide an input groove for load application.



The lock clamps to the control column at its narrowest point below the control wheel. Two hook-end rods, attached to the clamp, extend upward to a point where the hooks can be placed over the horizontal bar of the control wheel. A turnbuckle on each rod can be adjusted to position and lock the control wheel in a neutral position. The control wheel is then firmly held while rigging adjustments are being made.



The protractor is centered on the control wheel and clamped on by means of hook bolts. Set screws on the protractor permit adjustment so that the free swinging pendulum pointer and the protractor indicate zero, with the control wheel in the neutral position. Any movement of the control wheel is indicated directly in degrees of travel.

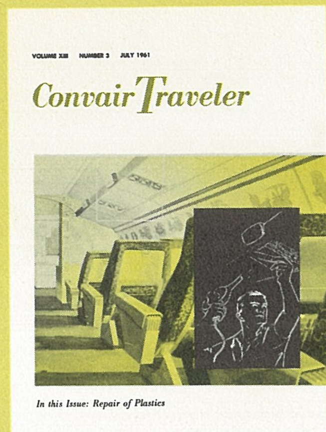
Control wheel operating forces may be applied and evaluated by routing a cable in the groove on the periphery of the protractor, and attaching a spring scale. Any desired torque can be applied to the control wheel by exerting a force on the spring scale.

Drawings may be obtained from Convair for local manufacture of the aileron lock and protractor.

VOLUME XIII NUMBER 3 JULY 1961

Convair Traveler

In this Issue: Repair of Plastics



OUR COVER

Plastics add beauty as well as durability to the plush interiors of Convair jet airliners. With little effort and a working knowledge of the composition and behavior of plastics, they are maintained in like-new condition. Artist — Norm Harrington.

Convair Traveler

VOLUME XIII NUMBER 3 JULY 1961

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IN THIS ISSUE

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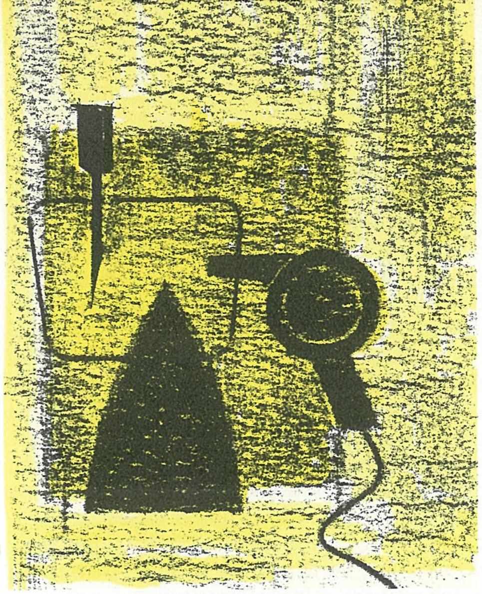


Repair of Plastics

PLASTICS ARE USED in many applications throughout the Convair 880/990 jet airliners. These applications range from structural components of thermosetting plastics reinforced with fiberglass, to decorative interior trim of thermoplastic materials. Despite the exceptional durability of most plastics, they can be damaged by hard usage or carelessness. In most cases, however, they can be readily repaired.

Much of the interior trim of the Convair 880/990 is of decorative Boltaron, a thermoplastic material of modified polystyrene, varying in thickness from approximately .032 to .062 inch. Boltaron is used in window frames, hatracks, seat trim, and many other applications requiring molded shapes of a decorative nature.

Ordinary dirt can be removed from Boltaron by scrubbing the surface with a mild soap and water solution. After cleaning, the surface is rinsed with clean water, and dried with clean cheesecloth. Soil marks can be removed from Boltaron with cleaning solutions. Stubborn soil marks can be removed with cheesecloth dampened with iso amyl acetate or technical grade amyl acetate. When cleaning with amyl acetates, light sweeping strokes should be used because these solvents are capable of dissolving Boltaron, and, if not applied sparingly and carefully, are likely to remove the surface finish.

Minor tears, scratches, and dents in Boltaron may be repaired by the careful application of heat and solvents. Separating surfaces can be readily cemented. Personnel anticipating repairs on Boltaron should practice on a similar piece of scrap material. The successful repair of damaged thermoplastics will depend largely on the skill of the worker and on meticulous workmanship.

For repairs requiring the cementing of Boltaron, the surfaces to be joined are first wiped with cheesecloth saturated with aliphatic naphtha. The joining surfaces are roughened with No. 1/2 sandpaper before applying the cement so as to aid in obtaining maximum adhesion of the bond. All dust must be wiped from the parts after sanding. A light coat of Vinacryl Solution 855-40A, American Resin Chemical Company, is then brushed on each surface and allowed to dry for 5 to 10 minutes. A thicker second coat is next applied to one of the mating surfaces and allowed to dry until tacky. This usually takes about one minute. The parts are then joined and held in place by weights or clamps for at least two hours to develop a bond of near maximum strength. Applying pressure for 8 to 24 hours is more desirable.

Dents, creases, and bent edges in formed parts may be smoothed out by the application of localized heat. An electric iron whose heat does not exceed 200°F is placed over a fiberglass cloth pad directly in contact with the damaged surface area. The iron is left in place for 5 to 10 minutes, and the progress checked. This process is continued until the part resumes its original shape.

Where possible, when reworking Boltaron, the part is blocked up and the spot to which heat will be applied is backed up. When applying heat to the thinner gages of material, the operation should be closely monitored because the heat transfer is more rapid through the lesser thicknesses. Heat applied to the back side of the damage at the same time will aid in maintaining the original shape. The part should always be allowed to cool, with the iron and pressure blocks in place.

Scratches and cuts through the top layer of Boltaron can be repaired by drawing just the right amount of methyl ethyl ketone (MEK) along the line of the cut to plasticize the damaged material. When the solvent evaporates, the cut or scratch is joined and "healed." It is advisable to employ the use of a thin glass stirring rod or a small camel's hair brush when applying the solvent to the damaged Boltaron, because larger tools tend to spread the solvent over too large an area. To finish the repair, the "healed scar" and the surrounding area may be spray-painted a matching color to blend with the rest of the material.

By the careful application of matching polystyrene mastic, small holes (1/4 inch maximum diameter), elongated drilled holes, or cracks starting from the edge of the material may be filled in to a matching contour. The repair can be reinforced by cementing a patch on the reverse side. Vinacryl Solution may be used.

The mastic for making repairs is prepared as needed by dropping a small amount of MEK on a scrap of matching plastic and scrubbing up the plasticized surface with a knife blade or spatula. The mastic is then applied quickly with the blade or spatula, adding MEK as needed to keep the mastic workable. Excessive working of the mastic should be avoided, and the surface area surrounding the repair should be cleaned by lightly scraping away excess mastic before it hardens.

Torn sections and large holes in Boltaron flat panels may be repaired in much the same manner as the smaller defects, except that the damaged area is cut out in a symmetrical shape and a patch of matching material and corresponding shape is fitted and cemented in the area. MEK is used to "blend" the seam.

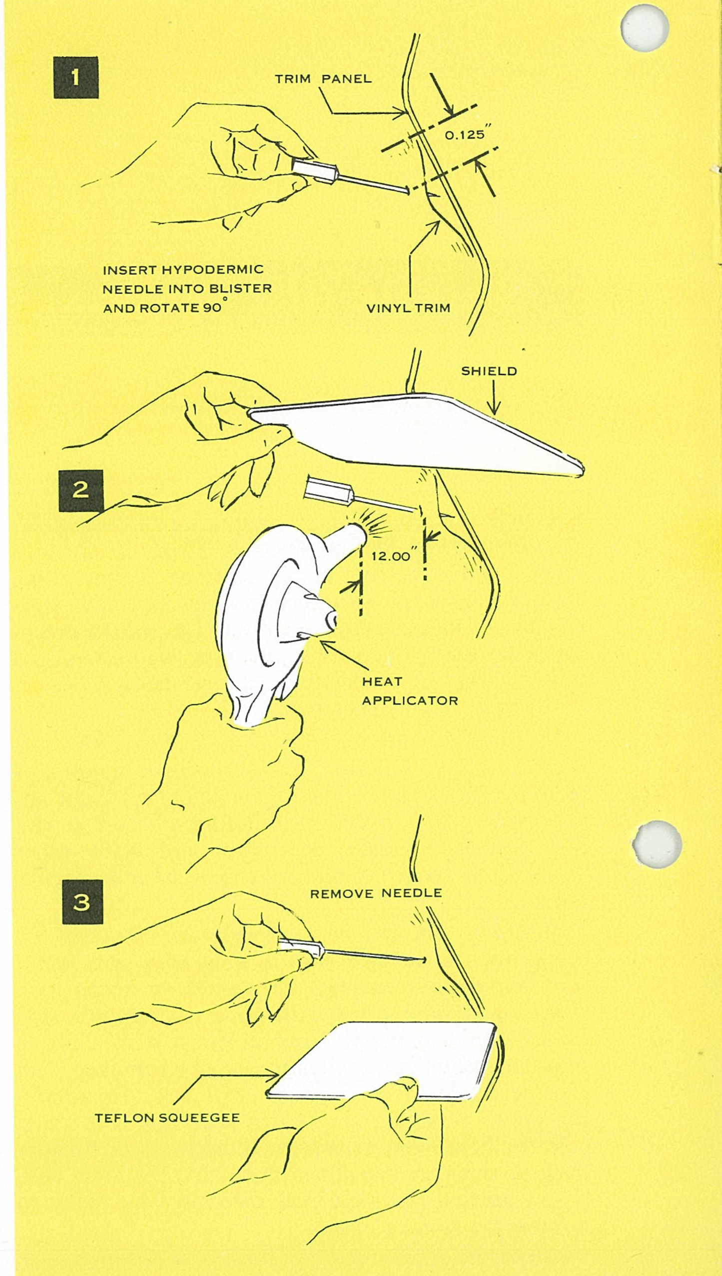
Formed or curved parts may be patched by heating both the patch and the reinforcement with a temperature not exceeding 150°F, and cooling between improvised mold blocks. The part to be repaired should not be placed in an oven. A hand-held heating gun, or blower, similar to a hair dryer, is more feasible for applying localized heat.

DURATRIM ANOTHER DECORATIVE PLASTIC trim widely used in Convair 880/990 jet airliners, is a comparatively thin thermoplastic material (.015 thick) that is bonded to interior sandwich panels such as partitions and wainscoting. Its surface is finished in a pattern or printed design. As a general rule, the methods and techniques used for repairing Boltaron can be used for this polyvinyl plastic. As this material is much thinner than Boltaron, greater care must be exercised during repairs, especially when applying heat and when cleaning the surface with solvent. It is difficult to match the design if it has been wiped away.

A blister that has formed on a Duratrim-covered panel may be easily removed by inserting a fine hypodermic needle (size 20 gage) and allowing the trapped air to escape. The needle should be inserted so that the resulting hole will be on the down-grain side of passenger vision. A delaminated area can be rebonded by carefully heating the area with a heat gun, taking care not to soften the material to the extent of damaging the finish, and then pressing down the surface with a soft rubber roller or Teflon squeegee.

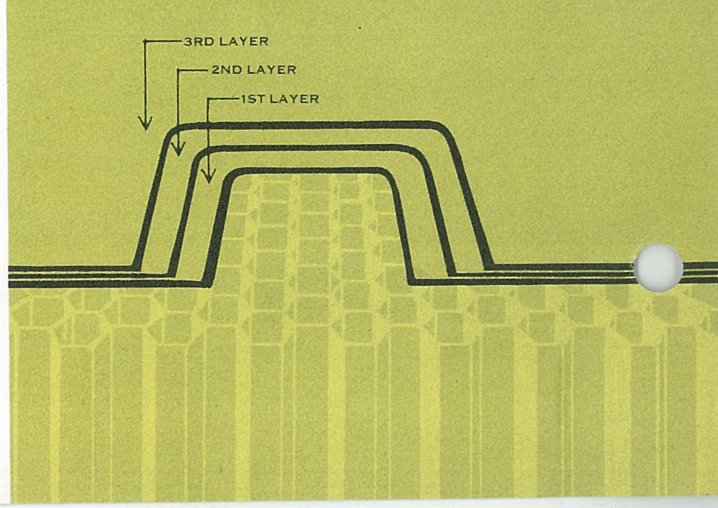
DUCTS WITH HOLES, cracks, cuts, and broken bonds can be repaired, providing the damage and consequent repair do not distort the duct, do not materially reduce its cross-sectional area, and do not interfere with the fit of the adjoining assembly. Properly repaired ducts will not leak.

The first step in repairing a duct with a crack or hole is to sand the surface for a distance of one or more inches beyond the damaged area. The dust is wiped off and the area is thoroughly cleaned with MEK, or a comparable solvent. Layers of No. 128 fiberglass cloth are then cut to cover the size and shape of the sanded area. Minor damage up to .75 inch requires two layers of glass cloth; damage extending from .75 to 1.25 inches requires three layers of cloth. A resin mixture of Epon 828, or equivalent epoxy resin, and HN-951 hardener, or equivalent, is then prepared, using the



VINYL TRIM BLISTER REPAIR

CUT FOR PATCH OVER HONEYCOMB



recommended proportions. To obtain an opaque black, 44-11 pigment or similar ingredient may be included in the resin preparation. The resin and fiberglass cloth layers are applied over the damaged area. The fiberglass should be completely saturated with resin, and no air should be trapped between the layers.

The final step in the duct repair is to cure the resin — eight hours at room temperature, or two hours at 170° to 180°F in an oven, or with infrared lamps. After the repair has thoroughly cured, it should be sanded smooth and checked for proper bonding.

Ducts with broken bonds may be repaired by sanding away the old adhesive from the faying surfaces of the parted bond. Again, it is important to wipe off the dust, and clean thoroughly with MEK or an equivalent solvent. Surfaces to be bonded are allowed to air dry. The faying surfaces of the duct are then coated with an adhesive mixture of Epibond 123 (or equivalent epoxy adhesive) and HN-946 (or equivalent) hardener in the recommended proportion, with enough black pigment for coloring.

It is important to fill all cracks to prevent air leakage. The parts are held together with polyvinyl alcohol (PVA) tape or contour clamps until the adhesive has thoroughly cured. Upon completion of the curing cycle, the repair is sanded smooth and carefully checked for proper bonding and the absence of leaks.

FIBERGLASS-COVERED HONEYCOMB PANELS retain approximately 75% of their original strength after repairing. (Repair of aluminum-skinned honeycomb panels is covered in the Convair 880/990 Structural Repair Manual.)

The extent of delamination about a damaged area may be determined by tapping the area with a half dollar, or comparable metal object. Dull, dampened sounds indicate a delaminated area. Layers of cloth are removed from the affected area until the honeycomb core is exposed. Each layer is stepped in toward the center of the damage so that the following layer will be smaller by one inch from the edge of the previous layer. Extreme care should be exercised to prevent cutting or scoring the underlying laminations. The corners of all cutouts should have a minimum radius of 1/2 inch.

Another method of removing the damaged skin is to feather the area with an abrasive disc, chucked in an electric or pneumatic drill. The opening should taper smoothly to the exposed honeycomb core. The feathered, or stepped down, area should then be sanded to remove any sharp edges. After sanding, all dust should be removed, and the area cleaned with MEK, or equivalent. No solvent should be allowed to enter the honeycomb core area or come in contact with the skin-to-core bond.

Patches of No. 181 glass cloth are then cut to fit each laminated cutout — the number of patches corresponding to the number of cutouts — and the patches thoroughly saturated with a resin mixture of 100 parts by weight of Epon 828 (or equivalent epoxy resin), and 9 to 10 parts by weight of HN-951 hardener, or equivalent. The fiberglass patches are positioned over the cutouts with the smallest first and ending with the largest. Pressure may be applied to the repair, provided that the core is not subjected to a crushing force.

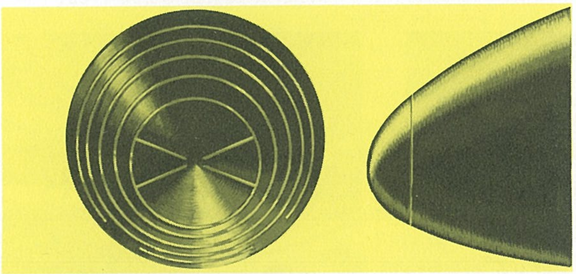
If the honeycomb core has been damaged, it should be repaired before applying the skin repair. The affected area should be carefully routed out to the opposite skin. All dust and chips should be cleaned from the opening. No solvents or liquids should be used. The core cavity should be filled with a resin mixture of 100 parts by weight of Epon 828, 10 parts by weight of HN-951 hardener, 10 parts by weight of Thiokol (or their equivalents), and 5 parts by weight of fiberglass mill ends or silica pellets. If damaged area of core is large, a piece of core may be set in and edge-bonded to the original core.

After the entire repair has cured at room temperature, the surface is sanded smooth, beginning with No. 240 sandpaper and finishing with No. 400 sandpaper.

FIBERGLASS LAMINATED NOSE RADOME repairs are divided into two categories: repair of minor damage and repair of major damage. Minor damage consists of nicks, pits, scratches, and abrasions that do not exceed a maximum of .010 inch in depth, 1/16 inch in width, and 6 inches in length. Major damage includes delaminations, fractured structural ribs, punctures deeper than .010 inch, cracks through more than two layers, and holes completely through the radome.

No major repairs are to be made on the radome forward of Station 120, or under the radome deicer boot.

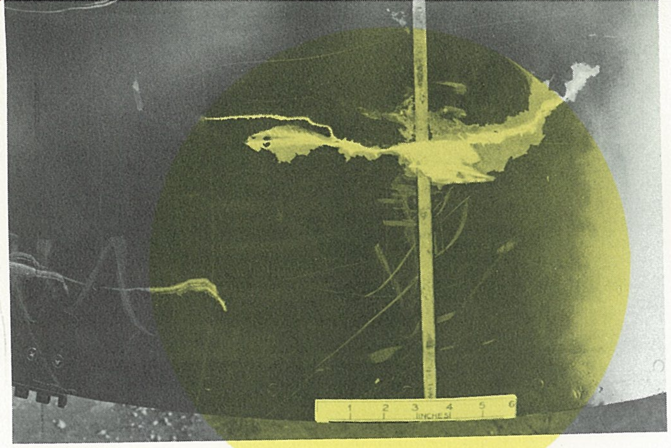
For minor repairs, the anti-static coating is removed for at least six inches beyond each side of the damaged area, by carefully sanding around the area and feathering toward the inside with wet No. 240 sandpaper, followed with No. 400 sandpaper. Dust is removed and the sanded area is wiped clean with cheesecloth moistened with aliphatic naphtha. After ascertaining that there is no delamination around the damaged area, the



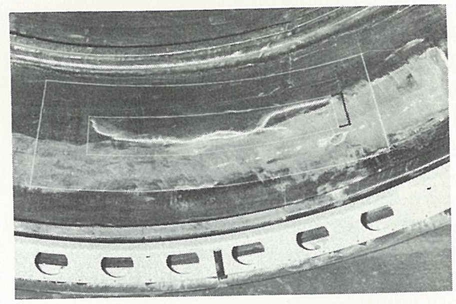
cavity is filled with Cat-a-lac white filler putty No. 467-2, mixed in accordance with manufacturer's instructions. Excess filler putty is removed by sanding the area flush with the laminated surface, using first No. 240 sandpaper, and then No. 400 sandpaper.

The filler is allowed to dry at ambient temperature for 24 hours, or, the repair may be cured at 250° ± 10°F for 15^{+5}_{-0} minutes. After the repair has cured, the entire repaired area is cleaned with cheesecloth moistened with aliphatic naphtha, and the anti-static coating (453-1-1, Finch Paint and Chemical Co.) is applied as required. Any lightning arrestor tape that has been removed is replaced.

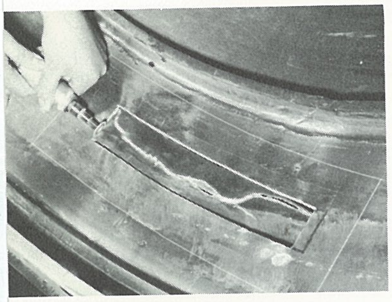
As with minor repair, major repairs (aft of station 120) require removal of the anti-static coating for at



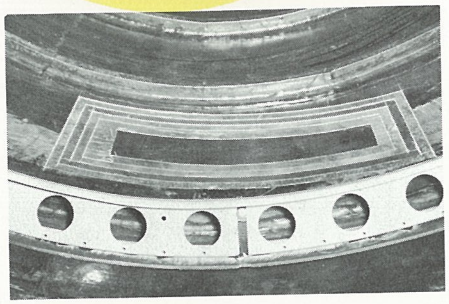
1 BASE OF RADOME SHOWING MAJOR DAMAGE CAUSED BY PIERCING



2 INTERIOR DAMAGE WITH RIB REMOVED

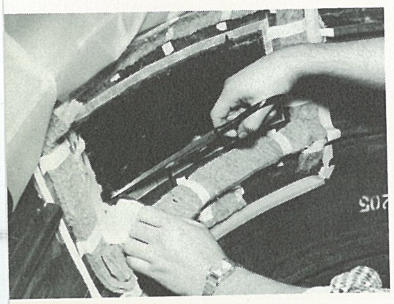


3 CUTTING OUT THE FRACTURED AREA

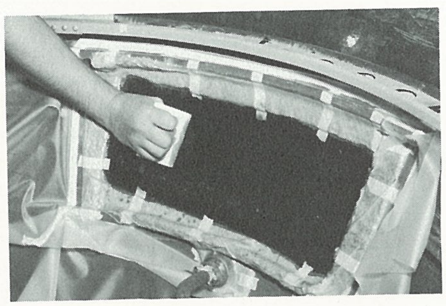


4 LAMINATIONS REMOVED BY STEPPING

5 FITTING GLASS CLOTH INTO CAVITY

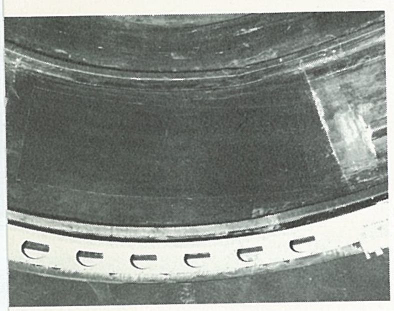


6 TRIMMING RESIN-SOAKED PATCHES

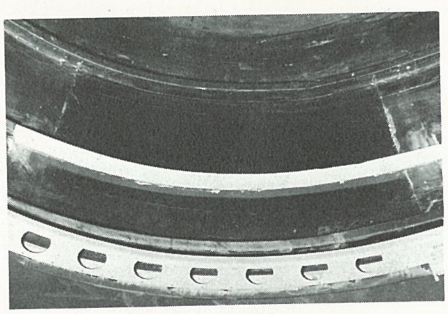


7 APPLYING SQUEEGEE TO VACUUM BAG

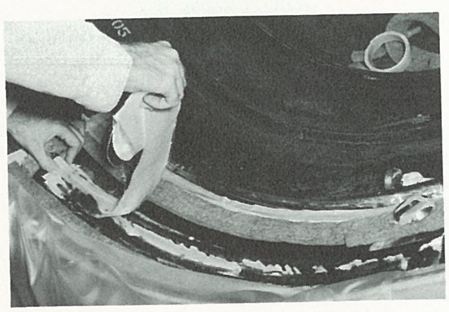
8 EXTERIOR VIEW OF FINISHED RADOME REPAIR READY FOR PAINT



9 INTERIOR REPAIR READY FOR RIB



10 NEW STRUX RIB SECTION IN PLACE



11 APPLYING GLASS CLOTH OVER RIB

12 FINISHED LAMINATION, RIB REPAIR

least six inches beyond each side of the damaged area. The repair area is then outlined with a sharp pencil, and the affected layers removed by stepping down toward the center of the damage every 1/2 inch. *Extreme caution should be exercised to prevent scoring or undercutting the underlying layers of glass cloth during the cutting operation.* Each layer is cut partially through and then lifted with a sharp thin chisel, so that it will break away cleanly. The cutout area is cleaned with cheesecloth moistened with aliphatic naphtha.

Patches of No. 181 glass cloth are then cut to conform to the penciled outline, and to fit into each stepped-down cutout.

The resin for major radome repairs is mixed as follows: 100 parts by weight of Epon 828 resin, or equivalent epoxy resin, and 17 parts by weight of RP-7A hardener, or equivalent. The resin should be weighed, and the hardener added and weighed in the same container to an accuracy of ±1.5 percent, in batches of less than 500 grams. The hardener should be thoroughly mixed into the resin for a minimum of 10 minutes; then, the mixture should be allowed to stand for a minimum of 15 minutes prior to use. This mixture has a work life of 3 to 5 hours.

The glass cloth patches are impregnated with approximately 43 percent content of the resin mixture by weight. A satisfactory method of thoroughly impregnating the patches is to spread the resin mixture on a sheet of PVA and place the patch over the mixture. A second piece of PVA film is then placed over the patch and the mixture is pressed through the cloth by a squeegee or roller. All air bubbles must be removed from the impregnated patch before the patch is positioned over the damaged area.

One coat of resin, 2 to 4 mils thick, is applied over the repair area with a knife, brush, or spatula, and the smallest of the impregnated patches is positioned in place. The wrinkles are rubbed out by working outward from the center using a Teflon squeegee. The next largest patch is fitted in the damaged area, and squeegeed, and so on until all the patches are in place. Then, a piece of No. 120 glass cloth, two inches larger than the repair area, is impregnated with resin and placed over the exterior surface of the repair, and worked free of wrinkles and air bubbles.

A vacuum bag is installed over the major repair, and the repair is cured under a vacuum pressure of not less than 12 inches Hg. One or two thermocouples are attached near the exterior side of the repair and connected to a temperature recorder; the repair is cured in the following consecutive cycles without interruption, and without cooling to room temperature.

Stage	*Temperature (°F)*	*Time (Hrs.)*
1	170 ±10	3 - 3½
2	150 ±10	1 - 1½
3	180 ±10	1 - 1½
4	250 ±10	9½ - 10½
5	295 ±10	2½ - 3½

The allowable time for shifting from one temperature to the next is 20 ±5 minutes.

At the completion of the curing cycle, if the repaired area checks out with a minimum Barcol hardness of 60, the anti-static coating is applied.

The fiberglass-reinforced structure or ribs of the radome should be repaired by cutting out the damaged section of rib and laminated glass cloth with a thin sharp chisel. Extreme care should be taken to preclude cutting or scoring the radome surface underneath. A piece of new 3/16-inch cell-size Hexcel fiberglass honeycomb core, or a piece of STRUX CCA-CH 167-168 material, is cut to fit into the rib cutout with a gap not exceeding .010 inch.

A corresponding number of layers of No. 181 glass cloth are cut to the same size as the original section. One hundred parts by weight of Epon 828 resin is mixed with 5 parts by weight of RP-7A hardener, and 8 parts by weight of HN-951 hardener, or their equivalents. Each ply of glass cloth is impregnated with resin by squeezing between PVA film, as with other repairs, and applied over the new section of honeycomb core, or STRUX. The plies of cloth are applied to match the original application. A coating of the resin mixture, 4 to 6 mils thick, is applied to all faying surfaces on the radome and cutout rib section.

The rib repair is "vacuum bagged" with a pressure of 12 to 14 inches Hg, and allowed to cure for 4 hours at 140° to 160°F, followed by 4 hours at 180° to 200°F. After curing, the repair is cooled at room temperature and the area sanded smooth with No. 320 wet or dry sandpaper.

RELATIVELY INCONSEQUENTIAL REPAIRS that are not covered by any particular procedure may be encountered from time to time. A practical knowledge of different plastics and surfaces will aid greatly in coping with these unforeseen instances, and a practical turn plus a little ingenuity will generally result in a good repair.

Epoxy resins are especially suited for repair jobs because of their excellent adhesive qualities. They will readily bond to themselves and other plastics and to aluminum and wood. Polyester is suited for most repairs involving plastics but does not bond to aluminum as well as does epoxy. It should be noted that unpainted polyester and polyesters without color pigments are susceptible to deterioration in direct sunlight.

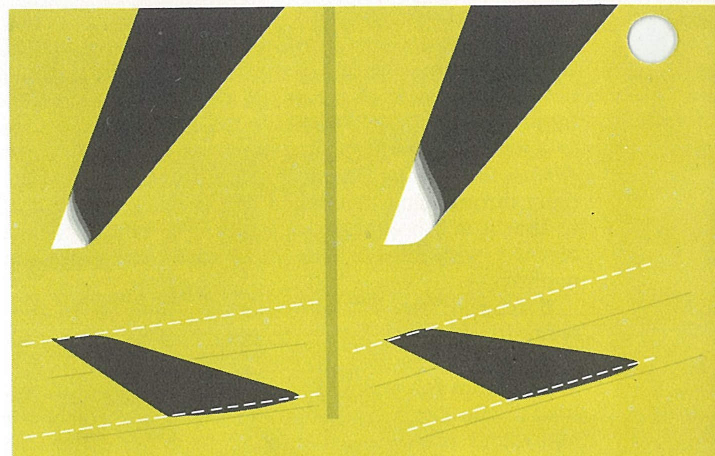
The addition of a very small amount of cobalt naphthanate (2/10 of one part by weight), or equivalent accelerator in the resin mix, will speed the curing process.

CAUTION

Do not mix cobalt naphthanate directly with any other accelerators or hardeners, because an explosion could result.

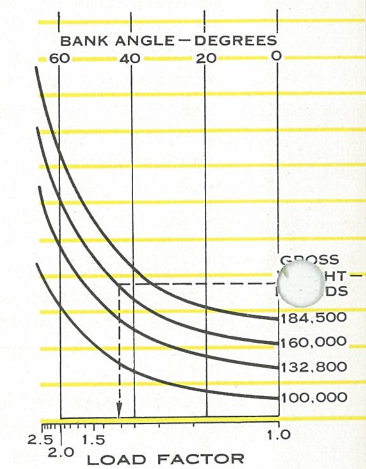
The length of time it takes thermosetting resin to cure is inversely proportional to the amount of heat applied. Under normal conditions, unaccelerated resin will cure at room temperatures in 12 to 24 hours — accelerated resin in about half that time. The average pot life of a resin mixture will range from a few minutes to an hour or more. The application of heat will cause resin to flow, or become a little thinner just before it begins to harden. Once the hardening process begins, it is too late to continue working the resin.

Stall & Buffet Longitudinal & Lateral Control



LOSS OF LIFT AND RELATIVE ANGLE-OF

Above, left, wing stall progression of a swept straight wing; at right, wingtip camber and incidence changes spread stall pattern along trailing edge, allowing conventional stall.



At right, Flight Manual buffet onset boundary chart illustrates fact that aerodynamic buffet can occur at any speed, with sufficient G loading.

WHEN A PILOT CHECKS OUT in a new airplane, he does most of his flying around the periphery of the airplane's flight envelope – into stalls; at maximum speeds and rates of climb and descent; with inoperative engines, spoilers, or stabilizer trim; through all the unpleasant maneuvers and emergencies he hopes never to encounter again, but for which he must be equipped if he does meet them.

A pilot will stall an airplane as a motorist with an unfamiliar car may slam on the brakes — not because he intends to stop that way thereafter, but because he wants to learn what the brakes feel like. An experienced transport pilot learning to fly an "880" does not necessarily have to reduce speed to the point of complete stall. He will take it near enough to that point, often enough, to find out exactly how it behaves down to the verge of complete stall.

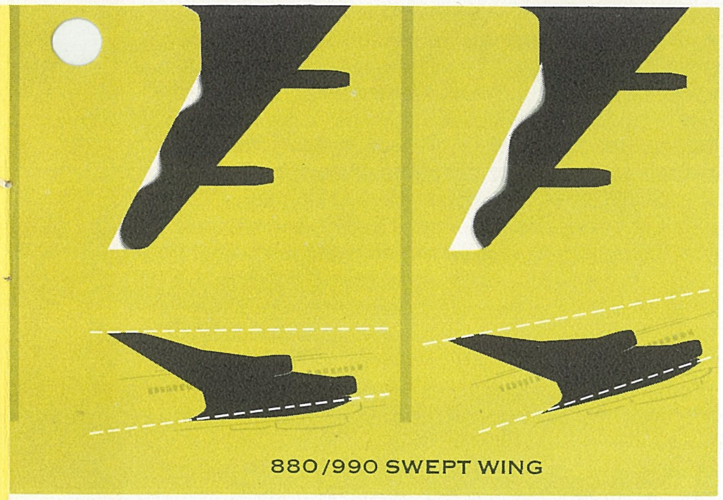
The natural stalling characteristics of the basic "880" are very similar to those of propeller transports . . . a somewhat unusual feature among the high-speed jets. In swept-wing aircraft, the wingtip tends to stall first. This causes an undesirable pitch-up moment . . . a stalled airplane should nose down. Also, asymmetric tip stall might roll the airplane. Some aircraft have extra lift devices at the wingtip, or extra drag devices inboard. In the "880," the pitch-up tendency was compensated for in basic aerodynamic design, part of it being achieved by "washout" (diminishing incidence) at the outboard end. There is a slight residual effect. The stall still begins in the outboard portion of the wing, resulting in a lightening of elevator stick force as the airplane slows. However, positive nose-up elevator stick force is required all the way down to complete stall; unless the stall is approached very slowly, the stick lightening may not be felt at all.

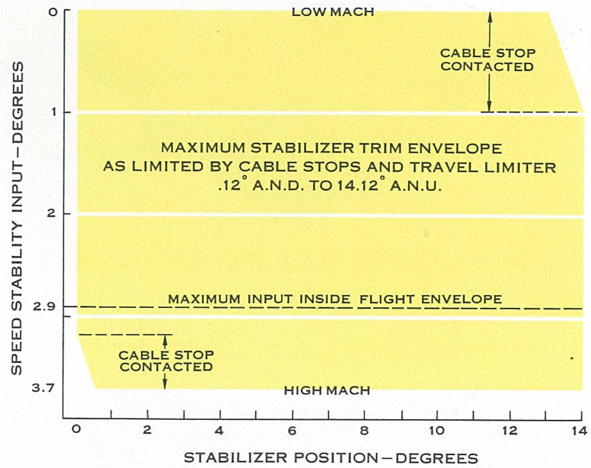
When the airplane stalls, the nose drops, and recovery is effected by standard means — by diving to pick up speed, or, more quickly, by lowering the nose and applying takeoff power. The pilot should be careful not to force recovery. Pulling back excessively on the control wheel before speed builds up could cause a secondary stall.

Stall warning buffet begins at approximately 1.2 V_S, well above the FAA requirement of 7% above stall speed. Flight Manual V_S speeds were determined under FAA-prescribed conditions, including a speed decay rate not to exceed one knot per second. At this stall approach rate, buffet will begin at approximately $V_S + 20$ kts. If the stall is approached more rapidly, buffet would begin perhaps a few knots nearer stall. At the onset of buffet, a slight alternating roll tendency may appear, but it is easily handled with lateral control. Buffet at the point of complete stall is as pronounced as in most piston-engine aircraft.

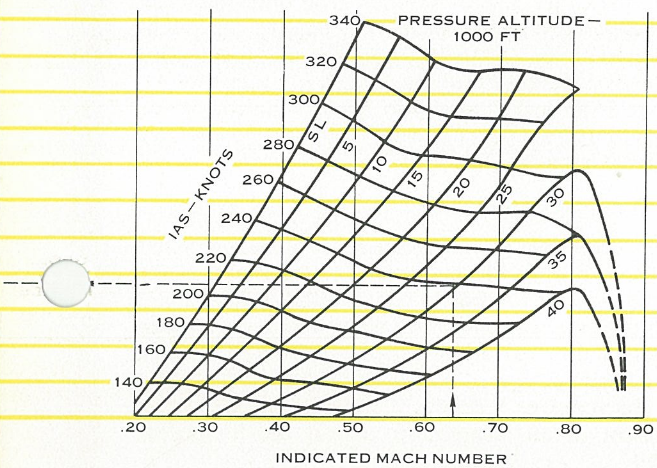
The addition of leading edge slats and flap modifications change the stall and low-speed buffet patterns. The foregoing, therefore, applies to the basic "880" only, and not to the heavier "880-M," nor to the Convair 990 aircraft.

There is another kind of buffet at the other end of the airspeed scale. The "880" never-exceed speeds are 400 kts IAS or Mach .884 indicated (Mach .89 corrected). A warning bell sounds when V_{NE} or M_{NE} is reached. The pilot will rarely reach a speed where the bell sounds without a warning compressibility buffet. A sonic shock wave begins to form over the wing at Mach .85 to .86; it can sometimes be seen as





-ATTACK OF SWEPT WING IN FLIGHT



a wavering line above the wing trailing edge. Behind the shock wave there is separation of the boundary layer air. Light buffet can be expected between Mach .87 and .88, and is quite pronounced at Mach .89. At 35,000 to 40,000 feet, "Mach buffet" may in fact be felt at Mach .83 or .84, and it could be induced by pulling positive load factors above approximately Mach .80.

At any speed, sufficient increase in load factor may cause buffet, as in steep turns or sharp nose-up maneuvers. Below Mach .80, this is usually thought of as "separation" or stall-type buffet, as distinguished from that caused by sonic compressibility turbulence. A chart in the Flight Manual provides buffet onset boundary curves showing relationships between gross weights, altitudes, airspeeds, bank angles, and G-load factors.

Speedbrake (spoilers) extension to a large angle of deflection causes buffet at high speed. This is common in current speedbrake designs; some commercial pilots avoid high-speed spoiler extension for fear the buffet may worry the passengers, though observation reveals that passengers are often less likely to be sensitive to slight buffet than are the pilots. Buffet also ensues when the main gear is extended for speed braking. In any approach, extension of all the landing devices — speedbrakes, flaps, landing gear — is accompanied by a slight low-speed aerodynamic buffet. This feels quite different from prestall or Mach buffet and the pilot will quickly learn to distinguish the types.

LONGITUDINAL CONTROL, SPEEDBRAKES

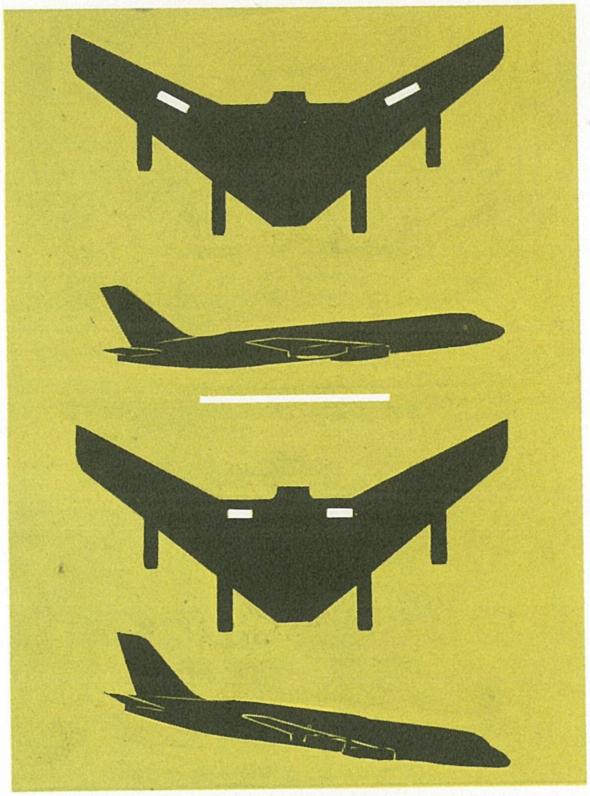
FLYING AN "880" is for the most part much like flying any other heavy airplane. It does fly a lot faster than a four-engine propeller transport, and control response is inevitably different; seemingly less sensitive in some respects, and more sensitive in others. Ailerons alone have less effect on lateral response; spoilers, more. Speed makes holding a specific altitude somewhat more difficult in that small attitude changes result in more altitude change. The net result is that the autopilot will be found to be more important than ever, for holding heading and altitude and for yaw damping.

The pilot in training, however, will not normally be using the autopilot. If he is new to jet transports, he will have to learn certain characteristics of swept-wing airplane longitudinal and lateral control, along with the specific techniques of managing stabilizer trim and speedbrakes.

High speed and the larger inertial mass of a big airplane require a pilot to plan further ahead in executing any maneuver. He must take more pains to make changes in attitude smoothly, to keep nose up in a turn, and to start leveling off from climb or descent a little sooner.

Stabilizer trim differs from elevator trim, chiefly, in that there is more of it. The whole stabilizer moves. It is pivoted just forward of the elevators. The leading edge can be lowered as much as 14° for nose-up trim. In the middle speed ranges, handling stabilizer trim is little different from handling elevator trim. At higher speeds, a certain amount of nose-up trim is supplied automatically, by a speed stability system utilizing a separate mechanism in the stabilizer screwjack assembly.

As speed increases, airflow changes cause wing center of lift to move outboard and aft, resulting in a nose-down moment usually termed "tuck." Maxi-



mum automatic trim to counteract tuck is 3.7°. Of this, up to 1.6° is governed by a Mach sensor; the remainder is programmed by a "Q" pressure sensor. It is therefore somewhat inaccurate to call the "880" speed stability system "Mach trim." The "Q" sensor begins adding trim at approximately 200 kts; the "Mach effect" input begins about Mach .78. With this speed stability system inoperative, enroute airspeed is limited to 335 kts, or Mach .73.

The pilot will probably start handling speedbrakes before his first stall. If the operation is begun with the airplane at anywhere near normal climb or cruise speeds, he will find that an "880" seems to take an incredibly long time to lose a hundred knots airspeed. Propellers at idle are effective aerodynamic brakes; but jet engines at idle draw in so much air that they offer practically no resistance and even contribute some thrust. The airplane is aerodynamically clean as possible, and, at high speeds, by comparison with propeller aircraft, glides like an arrow.

There are two spoiler-speedbrakes on each wing. They are essentially flat plates, hinged at the forward edge, and are raised by hydraulic actuators up to a 60-degree angle with the wing chord. Normally, they are operated differentially with the ailerons, providing some four-fifths of the lateral control moment. Actuated in unison — all four raised at once — they function as speedbrakes. They slow the airplane in part by their addition to the profile drag, and in part by their function as spoilers. They "spoil" the wing's lift, thereby making it necessary to increase angle of attack and thus add more drag.

The outboard spoilers are well aft of the wing center of lift. They generate a considerable nose-up moment by their deflection, and also by spoiling lift in the outboard aft section of wing. Consequently, when the pilot extends speedbrakes, he will note a distinct pitch-up tendency. He will quickly learn that if he attempts to correct for the pitch-up, he promptly loses altitude. Without correction, the airplane will usually settle back and stabilize — nose higher and drag effectively increased — at approximately the same altitude.

The inboard spoilers are also somewhat aft of wing center of lift, but their effect on longitudinal control is a nose-down moment. This is primarily due to breaking up the downwash across the tail surfaces.

These two opposing pitch moments are utilized by the "880" for emergency pitch trim. If the stabilizer mechanism should malfunction, a switch on the pedestal will allow operation of either outboard or inboard spoilers alone. The switch energizes motors at the hydraulic selector valve inputs to change the length of the valve actuator rods, thus in effect immobilizing one or the other pair of spoilers. The other pair can then be extended by the speedbrake handle. The pitching moment from 25° to 40° extension of the outboard spoilers is sufficient to supply enough nose-up trim for landing. Differential operation by the control wheel, through the aileron-spoiler mixer, will still be effective for lateral control.

LATERAL CONTROL AND DUTCH ROLL

CLASSIC AIRPLANE DESIGN THEORY, for some years, has maintained that an airplane should have approximately twice as much directional as lateral stability. This is not possible in the current swept-wing designs; the ratio is practically reversed. Nevertheless, sweepback is the most efficient design so far available for the high subsonic speed range. A degree of sweepback is the rough equivalent of an increase in critical Mach number by .013.

At the same time, with reference to lateral stability, 5° of sweep is equivalent to 1° of dihedral. This adds up to an oversupply of inherent lateral stability; the swept-wing airplane is thus inclined to be overly sensitive to lateral imbalance.

For jet flight training, there are two practical aspects of this theorizing: 1) a general rule, for manual flight, to beware of overcontrol in the roll axis; and 2) a necessity for a training program to include a thorough checkout in "Dutch Roll" characteristics.

With specific reference to flying the "880," it was mentioned earlier herein that the spoilers supply an average of four-fifths of the roll moment. Small movements of the control wheel actuate the ailerons alone, because of the designed "spoiler dead band." The controls are rigged so that a 10-degree wheel movement, on the ground, is required before the spoilers operate for lateral control. Airborne, the dead band is somewhat narrower; but, within the dead band, lateral response is comparatively slow.

Response from aileron use alone is sufficient for the small corrections necessary in ordinary straight cruise flight. At high Mach numbers, because of trailing edge flow separation, the aileron flight tab tends to be slightly less effective, but the vortex generators hold

separation to a minimum and make control more positive near neutral. The trim tab, incidentally, is thickened and blunt at the trailing edge, raising the upper surface nearer the separated airstream to increase trim effectiveness.

When the control wheel is turned far enough to bring the spoilers into action, the increase in lateral control effectiveness may lead to overcontrol. Spoilers will usually be providing roll moment at slow speed, after takeoff or during approach. It is important that the pilot acquire a feel for handling the wheel to maintain smoothness in maneuver and precise attitude control.

"Dutch Roll" is not much publicized, but it is certainly much discussed among pilots, and deserves some attention. It is characteristic behavior for swept-wing aircraft and even for some straight-wing aircraft with pronounced dihedral.

"Dutch Roll" was briefly described in a previous article as a roll coupled with yaw that reverses itself automatically. It may be touched off by a gust, or by inadvertent overcontrol. Wing sweep in a yawing airplane augments the tendency for the advancing wing to rise. The airplane is oversensitive to lateral imbalance, and somewhat slow to correct yaw. Therefore, the two corrective tendencies are out of phase, and the effect is a cyclical rocking and yawing motion that in some earlier swept-wing aircraft would continue until corrected, or would actually become divergent—would continually worsen — if not corrected. It is seldom actually dangerous, but it can be uncomfortable for passengers.

In the "880," "Dutch Roll" is not excessive or divergent. When induced purposely by yawing the airplane and then releasing the rudder, the roll will be 5° to 10° each side of wings-level after rudder release. With controls centered, or even hands-off, the "880" has enough basic stability to damp the roll slowly. The autopilot yaw damper, being quicker in response than human reaction time, stops "Dutch Roll" at its inception; if engaged after oscillation has begun, it will quickly stop the roll by rudder action alone.

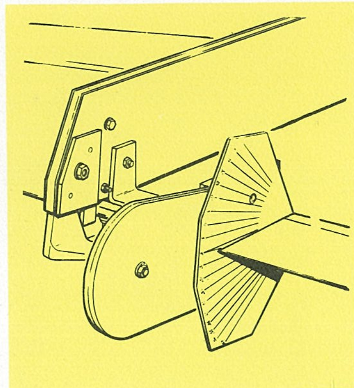
When it comes to manual flight, there is a little trick to the damping. Experienced pilots, checking out in swept-wing transports for the first time, have been known to battle "Dutch Roll" furiously for minutes without straightening out. Unfortunately, the typical reactions of the average pilot are likely to add correction for roll and yaw at the precise instant when it will increase the oscillation.

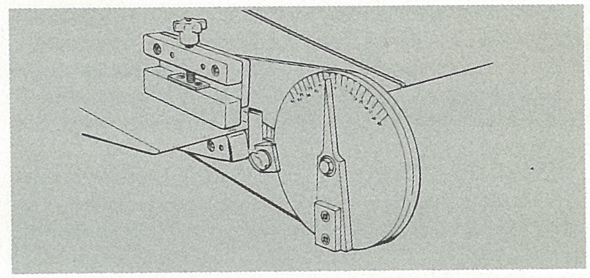
Convair pilots recommend that manual recovery be made by applying slight crossed-control pressure, and holding it, in the same direction, until a steady slip is established. Then, the controls can be released slowly to straighten out. This is a sure method. With sufficient practice, the pilot may learn to "deadbeat" the roll almost instantly, by acquiring a feel for feeding in the exact amount of pressure necessary against the low wing just as it starts to rise, with corresponding (opposite) rudder input. The important thing, however, is not to "chase" the roll; this nearly always ends up in a bigger oscillation than ever. The inertial lag of a heavy airplane in responding to controls makes it difficult to time the inputs to stop the oscillation. Steady crossed-control pressure, held through several cycles if necessary, will bring an "880" into line very quickly.

The maneuver must be practiced at varying speeds, altitudes, and roll angles until the pilot's "instinctive" reactions are trained. He must be equipped to deal with "Dutch Roll" on instruments, with an engine inoperative, at near stall speeds, with or without flaps, with spoilers deactivated — that is, under all the conditions under which it might occur.

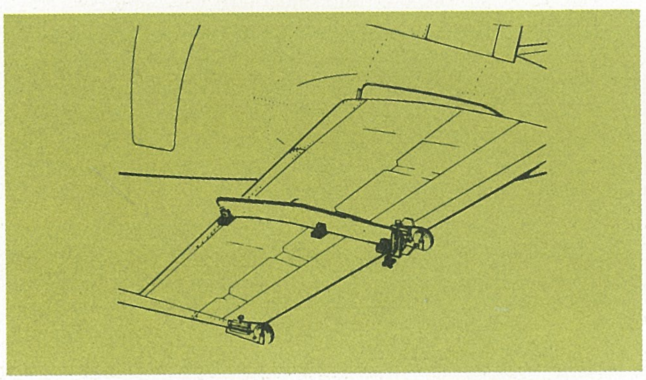
One more caution — a familiar one applicable to flying any airplane — should be re-emphasized during jet flight training: *do not forget to cross-check the instruments, not only between the duplicated ones on pilot's and copilot's panels, but within the flight instrument systems.* This means checking horizon against turn-and-bank, altimeter against rate-of-climb, IAS and TAS against the others, to be assured that they are mutually consistent readings.

This is particularly important at jet aircraft speeds, where small indicator errors might occasion large-scale displacements of an airplane in flight. With the best instrumentation available, needles sometimes stick, capacitors develop current leaks. The most precise vertical gyro precesses a little; after a turn, for example, the horizon indicator may show a bank or pitch angle that is momentarily misleading. The aberration is rarely more than a degree or two — less than a dot-width – and is seldom important. Under certain conditions of instrument flight, it could be important, unless the pilot is in the habit of constantly cross-checking, and hence is familiar with instrument behavior and is mentally prepared.





Elevator and Tab Rigging Tools



ELEVATOR AND TAB RIGGING is accomplished on the Convair 880 production line with the aid of four rigging tools. These are right- and left-hand elevator holding fixtures, and right- and left-hand dual protractor tools.

The holding fixture is contoured to the upper surface of the stabilizer and extends aft beyond the trailing edge. The fixture, when positioned approximately six inches outboard of the tab, is attached by screws to the stabilizer. A clamp on the holding fixture secures the elevator in the streamlined, or neutral, position.

A protractor tool fits over the trailing edge of the stabilizer at the outboard end of the tab. The protractor tool shows both elevator and tab movements with respect to the stabilizer, and does not require that the airplane be leveled to secure direct movement measurement. On the outboard face of the protractor tool is an adjustable protractor with a free-swinging pendulum pointer for checking elevator movement. On the inboard side of the tool is a fixed protractor for checking throw of the tab.

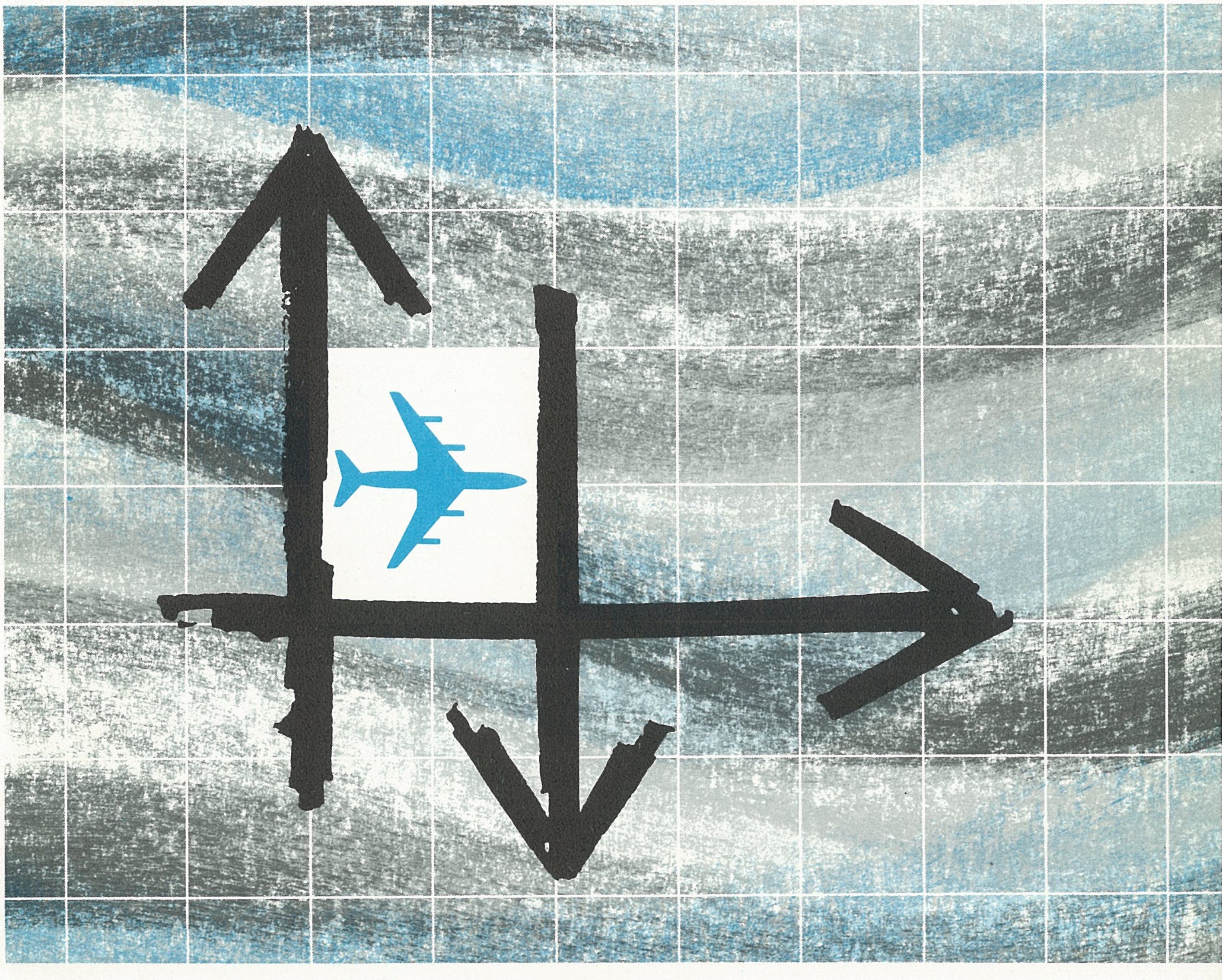
In use, the adjustable protractor is positioned and clamped so that the free-swinging pointer reads zero degrees; then, the holding fixture is removed. Any movement of the elevator will be indicated directly in degrees on the face of the adjustable protractor.

The fixed inboard protractor face (which is read by sighting along the upper surface of the tab) indicates the degree of movement of the tab with respect to the elevator.

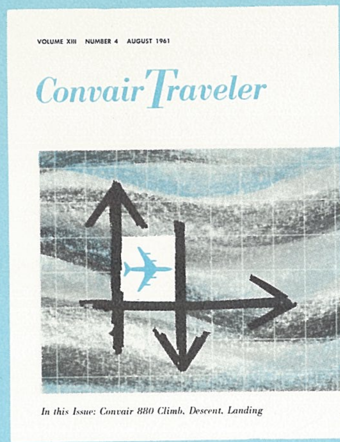
Drawings of these tools for local manufacture are available from Convair. The tool numbers are: Elevator Holding Fixtures, 22-00003-903 and -904; Dual Protractor Tools, 22-00003-901 and -902.

VOLUME XIII NUMBER 4 AUGUST 1961

Convair Traveler



In this Issue: Convair 880 Climb, Descent, Landing



OUR COVER

Willis Goldsmith, artist, pressed for an interpretation of this issue's cover, denies everything. "It is NOT an abstraction; it does not mean that airplanes fly up, down, and sideways." It's a cover design, and he likes it.

Convair Traveler

VOLUME XIII NUMBER 4 AUGUST 1961

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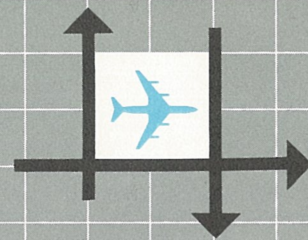
IN THIS ISSUE

A digest of operation and service published monthly by the Service Publications Sections of Convair Customer Service Department in the interest of Convair operators. Communications should be addressed to the Manager of Customer Service Department, Convair, San Diego 12, California. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without specific approval of their cognizant organization.

GENERAL DYNAMICS | CONVAIR

880 Flight Characteristics

CLIMB, DESCENT, LANDING



CLIMB SPEEDS DEPEND in part on airline or specific route demands, and frequently on Air Traffic Control instructions. So far as the "880" itself is concerned, the most desirable enroute climb speed — the most economical and not far from the best for block-to-block time — is 345 kts IAS up to an altitude (about 30,000 ft) where 345 kts IAS intercepts Mach .8 (.795 M_i), and Mach .8 thereafter, regardless of gross weight. Severe turbulence would limit climb or descent speeds to 249 kts IAS, the gust penetration limit speed.

Some rule-of-thumb formulas for "880" airspeeds might come in handy for use when a quick approximation is needed.

Speeds for best angle and best rate of climb depend on gross weight. Two figures to remember are that best angle of climb at 120,000 lb gross weight is at 200 kts IAS; best rate of climb is at 250 kts IAS. For each 10,000-lb difference in weight from 120,000 lb, add (or subtract) 7 kts. Best angle of climb for 110,000 lb is obtained at 193 kts, for 130,000 lb at 207 kts, for 140,000 lb at 214 kts, etc. Best rate of climb is 50 kts higher: for 110,000 lb, 243 kts; for 120,000 lb, 250 kts; for 130,000 lb, 257 kts, etc. These figures hold for 2-, 3-, or 4-engine climb.

Another convenient approximation is that at normal cruise settings, 1% of rpm is equivalent to 4% of thrust. From this, it may be seen that if thrust from one engine is lost (25% of total thrust), 2% more rpm will be needed on the remaining engines to maintain any given thrust; if two engines are out, 6% more rpm will be needed on the two remaining engines.

Rates of climb and descent, either in gradient or in degrees, are related to the slant distance the airplane travels – hence, to true airspeed. A few constants relate TAS and rate-of-climb indicator readings to climb gradients and glide slopes.

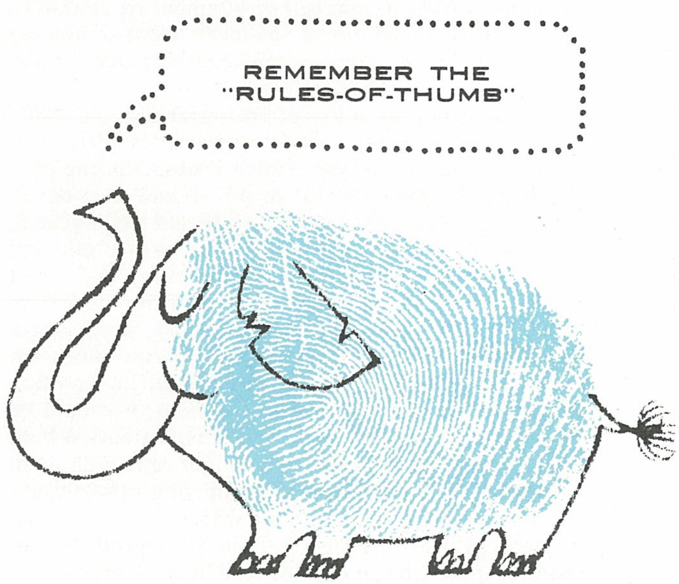
Rate of climb is very nearly TAS times number of percent of gradient (more precisely, $TAS_{KTS} \times \%$ gradient $\times$ 101.3). The required second segment 3% climb gradient at V_2, for example, is a rate of climb at least $3 \times$ TAS at V_2 (remembering that V_2 is in IAS). Or, climb gradient is approximately rate-of-climb reading divided by TAS.

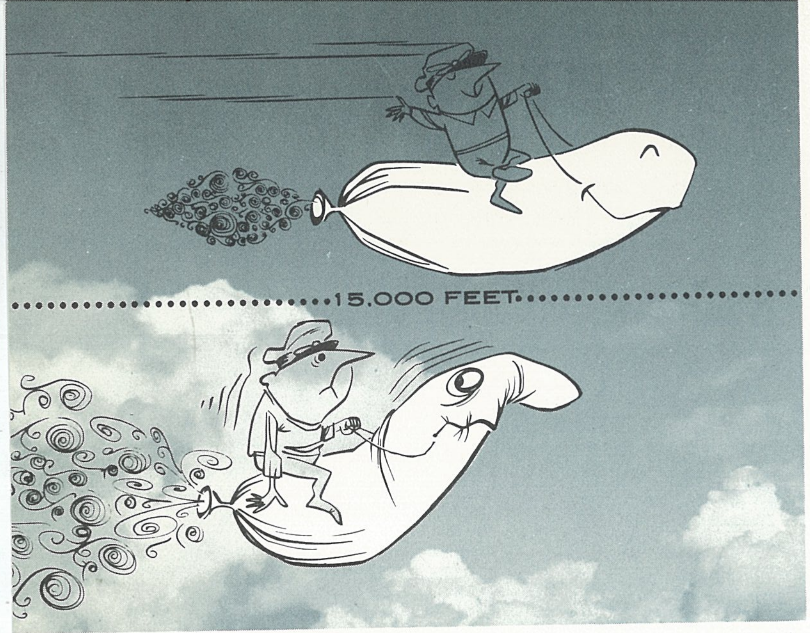
In terms of angle of climb or descent, rate of climb is the sine of the angle $\times 101.3 \times TAS_{KTS}$. Adding zero to TAS gives rate of climb or descent at an angle just under 6°. Very loosely, half this figure is somewhat less than a 3° slope, and more than a 2½° slope. For more accurate figures of ILS glide slopes, ground speed can be estimated by allowing for known wind component. Then, GS $\times$ 4.4 is a very close approximation (within 1%) of rate of descent on a 2½° slope; GS $\times$ 5.3 for a 3° slope; and GS $\times$ 6.2 for a 3½° slope. For example, an approach GS of 150 kts requires 660 ft/min for a 2½° descent, 795 ft/min for 3°, and 930 ft/min for 3½°.

HOLDING AND DESCENT

For reasons of fuel economy, jet aircraft hold at high altitudes when possible. This is pretty well known by now; but the reason for the fuel economy is not so widely understood among non-pilots, although it is apparent to pilots. It is not so much that jet aircraft use less fuel in cold or rarified air, or meet less air resistance, but that they are permitted to fly faster while holding – not only at higher TAS but at higher IAS. An airplane needs enough speed to operate beyond "the back side of the curve" to be efficient in power usage.

An "880" begins to fly efficiently at an IAS approximately equal to its weight in thousands of pounds plus 100 kts; e.g., for 130,000 lb gross weight, holding speed is approximately 230 kts. At this speed, it requires the least thrust (usually 85% to 86% rpm) to maintain altitude. But (as of this writing) the official maximum holding speed below 15,000 ft in a traffic control area is 180 kts. At 180 kts, well below "880" usual holding speeds, angle of attack and drag are





greater, and fuel consumption necessary to maintain altitude may be one and a half times as much, at any given altitude. Above 15,000 ft, fuel consumption is somewhat less, and below 15,000 somewhat more. The principal factor, however, requiring high-altitude holding is the ATC low-altitude airspeed limitation. If permission can be obtained for higher airspeed, the fuel consumption penalty for holding at lower altitudes is comparatively minor.

Normal descent with a clean airplane can be made by retarding power levers and nosing down to maintain speed as desired, up to normal operating maximums ($V_{NO} - M_{NO}$, 373 kts IAS or .884 M_i). From considerations of passenger comfort, deck angle is usually the limiting factor at high altitude. Engine rpm should be kept above the minimums specified in the Flight Manual, to supply pressurization and anti-icing during descents.

Low-speed rapid descent may be made by reducing power and extending spoilers until speed is below .825 M_i and 318 kts IAS; extending nose and main landing gears to reduce speed still further; and extending flaps by increments as speed drops to the upper speed limits for various flap settings, until full 50° extension is reached at 194 kts IAS. A rate of sink of 6000 to 9000 ft/min can be attained. At 20,000 ft, cabin pressure can be at sea-level; from a holding pattern at this altitude, descent can be made rapidly without passenger discomfort.

In emergency, as in loss of pressurization, the "880" can be brought down considerably faster. Passenger comfort being secondary in such a situation, the pilot can bank sharply — to 30° or 40° — and start down, extending speedbrakes immediately and main gear at any speed below $V_{NO} - M_{NO}$. With power cut and full speedbrake and main gear extension, V_{NO} is not likely to be exceeded. Rate will be from 12,000 to 15,000 ft/min. Put more dramatically, a passenger can descend about three-quarters as fast inside an "880" as he would if he were outside, in free fall.

In levelling out after a steep descent, it should be remembered that gear and speedbrake extension both tend to nose the airplane up, and that retracting them causes a pitch-down moment. Applying power noses the airplane up slightly. It is obvious, also, that an airplane as heavy as the "880" in high-speed descent requires quite a bit of altitude lead in leveling out.

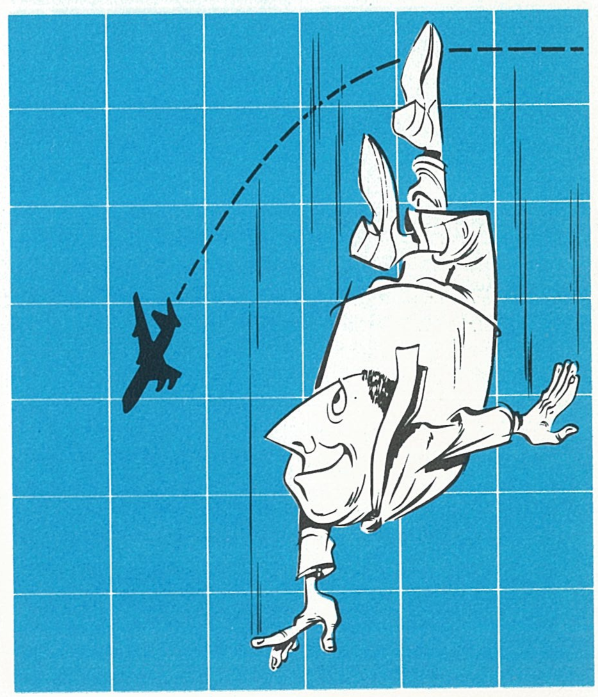
LANDING

The reference, or over-the-fence, condition specified in CAM 4b for establishing landing field length is an airspeed of 1.3 V_S at 50 ft above the end of the runway. This is generally accepted as sound flying technique. The 1.3 V_S speed (V_{REF}), in the "880," permits good control in all three axes; the 50-ft height insures against undershoot and enables the pilot to touch down approximately 1000 ft down the runway.

Touchdown speed is high in the jet transports. At a typical 140 kts reference speed, the airplane is traveling 236 ft per second. The necessity for accurate control of both speed and altitude is evident. Every knot in excess of V_{REF} adds at least 27 ft to the runway length necessary. In a 3° glide slope, some simple trigonometry shows that 50 ft more over-the-fence height will require 957 ft more runway. The penalty for floating just off the ground is correspondingly greater; deceleration airborne is always much less than on the ground.

In the standard pattern, the airplane will be slowed to below 200 kts at 1500 ft above the field on the downwind leg, speedbrakes retracted, speed allowed to decay, and landing gear extended on downwind or base leg. Flap extension is governed by IAS — 30° at $V_{REF} + 20$ kts, 40° at $V_{REF} + 10$ kts, 50° at V_{REF}. With full 50° flaps, approximately 90% rpm is required for level flight. Usual approach rpm is 85% to 88%, with a rate of descent of 700 to 800 ft/min on base leg and final.

Low ceiling and visibility circling approaches can be made as with any aircraft, with a side downwind approach, or, overhead with procedure turn. The radius of turn of an "880" in a 30° bank at average approach speed is about three-quarters of a mile. A side downwind approach, therefore, should be at least 1½ miles abeam of the runway.



To attain 1.3 V_S over the threshold, speed must be accurately managed throughout the approach. In an ILS approach, the airplane should be maintained on the glide slope by use of power for large corrections, and by elevators for small changes. Power is usually not reduced to idle until the flare. If a propeller airplane comes in too fast in a power-on landing, the pilot can often chop throttle and depend on propeller drag to slow him down; but an "880" that is inclined to float over the runway must be brought down by dropping the nose slightly.

Where a number of pilots, experienced in propeller transports, are learning to fly jets, there are likely to be a few harder-than-necessary landings. Military statistics indicate that all jet aircraft pilots are more likely to undershoot the runway than to overshoot. This is attributed partly to the high sink rate, partly to the high angle of attack. An "880" comes down a 3° glide slope in a 3° or 4° nose-up attitude. In the flare, the nose will merely be raised a little more and the tendency is to over-rotate. Optimum angle of attack for an "880" at touchdown is 8° to 9°; 12½° will drag the aft fuselage.

After the main gear wheels touch, the nose is brought down by the elevator, usually assisted by braking. Then the spoilers can be raised, to kill lift and increase brake effectiveness. Spoilers should not be raised until the nose is well down; the pitch-up moment previously noted might, if not checked, drag the tail. As during takeoff, some forward pressure on the control column to keep the nose wheel firmly on the runway will help stabilize the landing roll, particularly if there is crosswind. Aerodynamic control is effective for ordinary purposes down to 70 kts; nose wheel steering is often not required until turning off the runway.

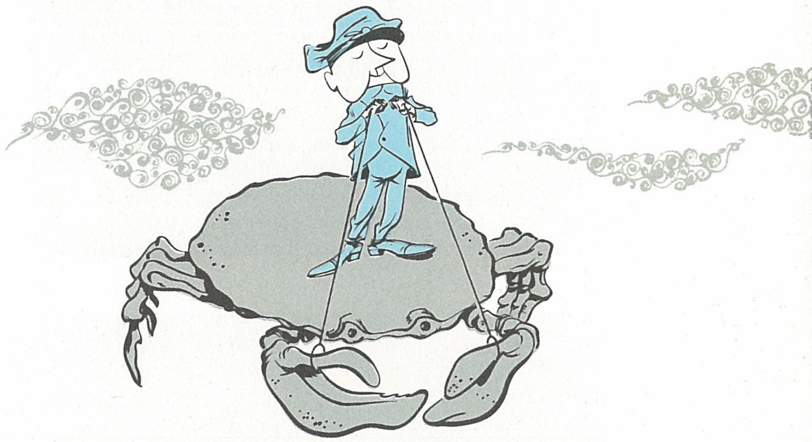
The CAR landing field length is based on the ability of the airplane, as determined by flight test, to stop on dry concrete within 60% of the required field length; the remaining 40% is allowance for overshoot, overspeed, or adverse runway conditions. While the pilot should be able to avoid the first two, he hasn't much to say about the quality of the runway surface, or the amount of snow on it. On an icy or rain-slick field, the pilot's best ally in stopping an "880" is the fact that it was certificated without reverse thrust taken into account. Jet engine reverse thrust may never be quite as effective as a reversed-pitch propeller, but it is a powerful aid.

Up to 100% rpm reverse thrust can be used initially; and 88% rpm below 70 kts, for not more than 30 seconds altogether. Ordinarily pilots use it less time than this; it is most effective, in contrast to wheel braking, at higher speeds. Also, re-ingestion of exhaust air may cause compressor stall at low speeds, particularly in a crosswind. If compressor stall occurs, power must be reduced promptly.

The maximum amount of wheel braking is obtained by applying full pedals and letting the anti-skid system take care of overbraking. This is not true of anti-skid systems on many aircraft, but it is true of the "880" system.

Parenthetically, on the subject of braking, one caution may be mentioned; it is applicable to any transport but more important in aircraft as heavy as the "880." It is well recognized that braking becomes less effective as speed goes up; less often mentioned is the converse, that brakes can be uncomfortably effective at very low speed. Jamming on a car's brakes at five miles an hour stops it with a heavy jolt. A transport pilot should also remember to ease up on brake pressure as the airplane slows to a stop.

Crosswind landings can be made by either the sideslip or crab methods, or by a combination of the two. It is possible that pilots of jet transports are inclined to favor crabbing, because of the likelihood of dragging the outboard pod (at 7° wing down). Cautious use of lateral control is as important during landing as during takeoff. The weathercocking effect of asymmetric spoiler deflection must be taken into account in controlling the airplane both before and after touchdown.



With all four engines operating, a go-around can be safely made from 1.3 V_S at 50 to 100 ft above the field. The single-spool CJ-805 engines accelerate from approach rpm to 103% in two or three seconds. The procedure is to advance the power levers, pull the nose up, and, as soon as airspeed reaches reference plus 20 kts, to retract the flaps from 50° to 30°. It is better to partially retract flaps before landing gear because full flap extension causes more drag than the gear. The gear can be retracted when climb is established, and the flaps retracted further as speed increases during climbout.

In landing with one or two engines inoperative, it is important not to allow speed to drop too far until the pilot is sure he will not have to go around. Minimum control speed for three-engine operation is that given in the V_{MC} chart in the Flight Manual. Minimum control speed on two engines is 159 kts IAS. Flaps should not be extended beyond 30° until landing is assured, as a wave-off cannot be made on two engines with full landing flaps.

Landing with either one or two engines inoperative, the pilot should remember, before he cuts off power, to reduce the trim used for asymmetric thrust. Otherwise, excessive control inputs will be required during the landing flare. Reverse thrust from two balanced engines can be used. With two engines out on one side, the remaining inboard engine can be used for reverse thrust if necessary.

DRAIN HOLES
Convair 880/880-M

THE ATMOSPHERE CONTAINS a certain amount of moisture which readily turns to water when it condenses. When an airplane lets down from the freezing levels of high-altitude flight to warmer areas, condensation forms in those compartments and pockets that are open to atmosphere. Unless these accumulations of water can escape, they pose the threat of turning to ice and interfering with controls and mechanisms when the aircraft enters freezing conditions. Added to the water from condensation are the accumulations of water from precipitation and airplane washdowns.

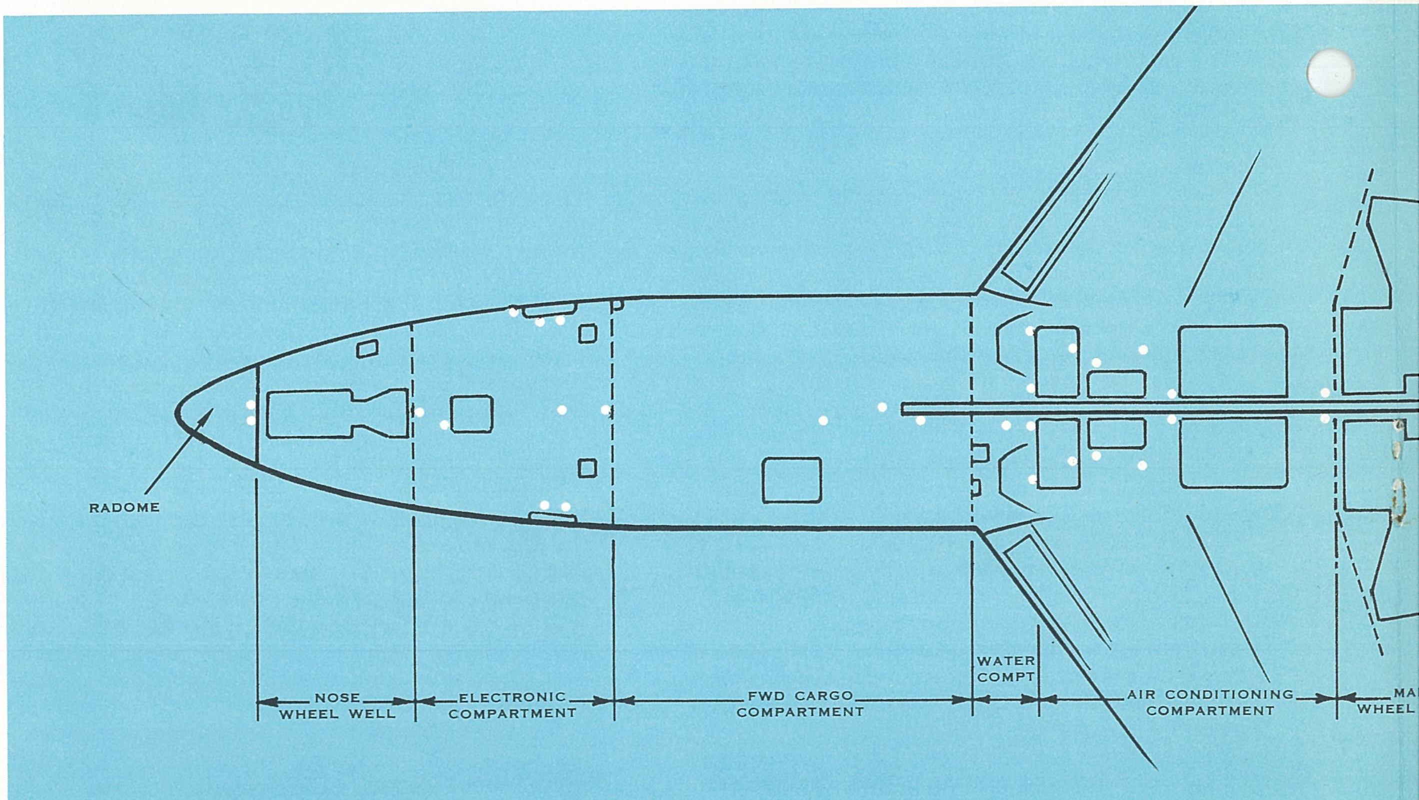
All compartments of the Convair 880 jet airliner, that are susceptible to moisture and water, have draining provisions at their lowest points. There are over 300 exterior drain openings in the Convair 880 — 51 in the fuselage, 67 in each wing (97 on the 880-M), 24 in each engine pod-pylon, and 24 in each horizontal stabilizer.

Drain holes and avenues of escape must be kept open and free of debris; otherwise, excessive ice buildup in the control mechanisms could result. All exterior drains are easily accessible for inspection. An internal drain hole in the torque box of each horizontal stabilizer can be reached through the aft fuselage access door.

The vertical stabilizer and rudder have draining provisions within their structure, permitting condensation to drain out existing holes. Moisture in the rudder escapes through holes in the bottom rib of the rudder. Because of the vertical configuration of the rudder, there is little possibility of water accumulation in this area.

The pilots' sliding windows have drain provisions in their lower guide tracks to permit draining of rain and moisture accumulations. The drain is routed down along the sides of the fuselage to an opening in the underside of the fuselage just forward of the electrical compartment access door.

The lower pin receptacles in the thresholds of the main entrance and service doors have drains with openings in the sides of the fuselage just below each



FUSELAGE D

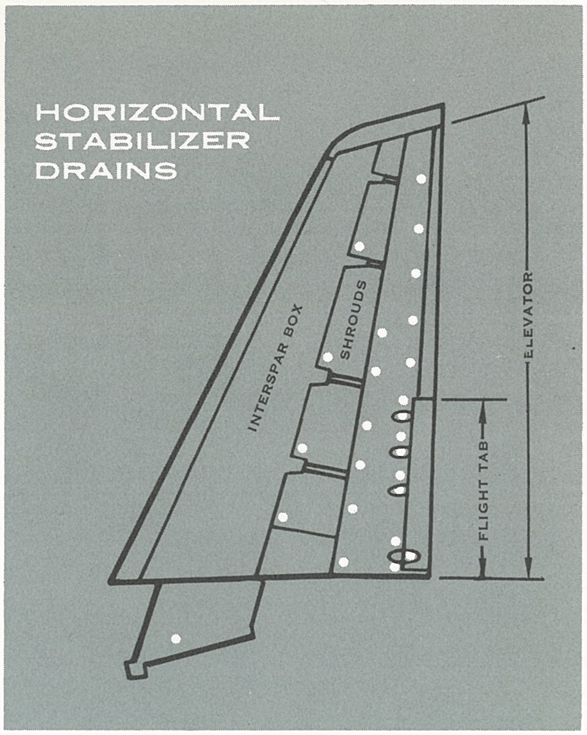
door. These are drained by removing the cover plates in the skin. The forward and rear main entrance door hinges are equipped with drain tubes that lead to openings in the side of the fuselage just forward of each door.

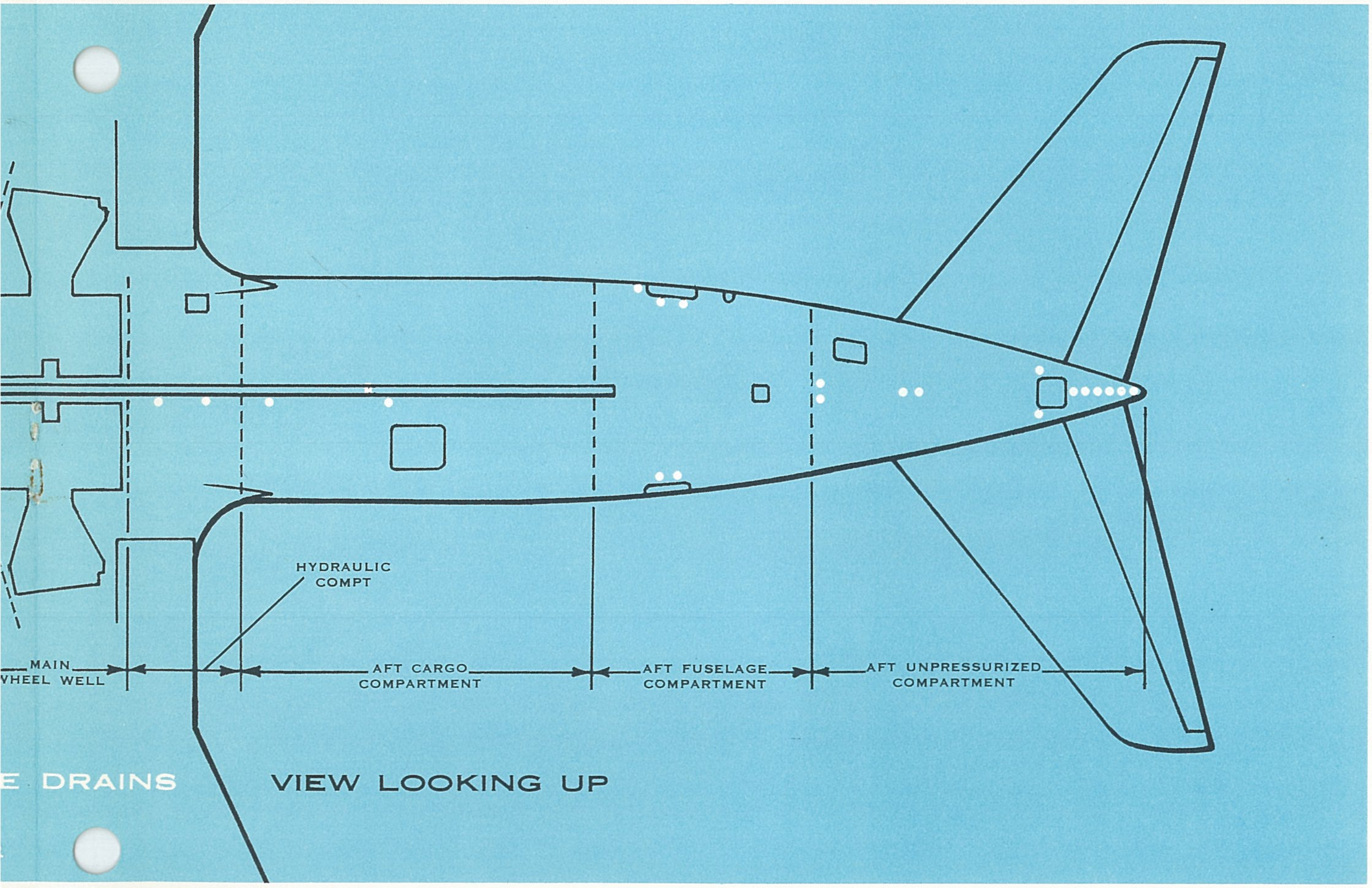
Most drain holes are ¼ inch in diameter. Two holes in the unpressurized section of the fuselage, aft of the pressure bulkhead, are ½ inch in diameter to provide rapid drainage and to minimize the possibility of freezing.

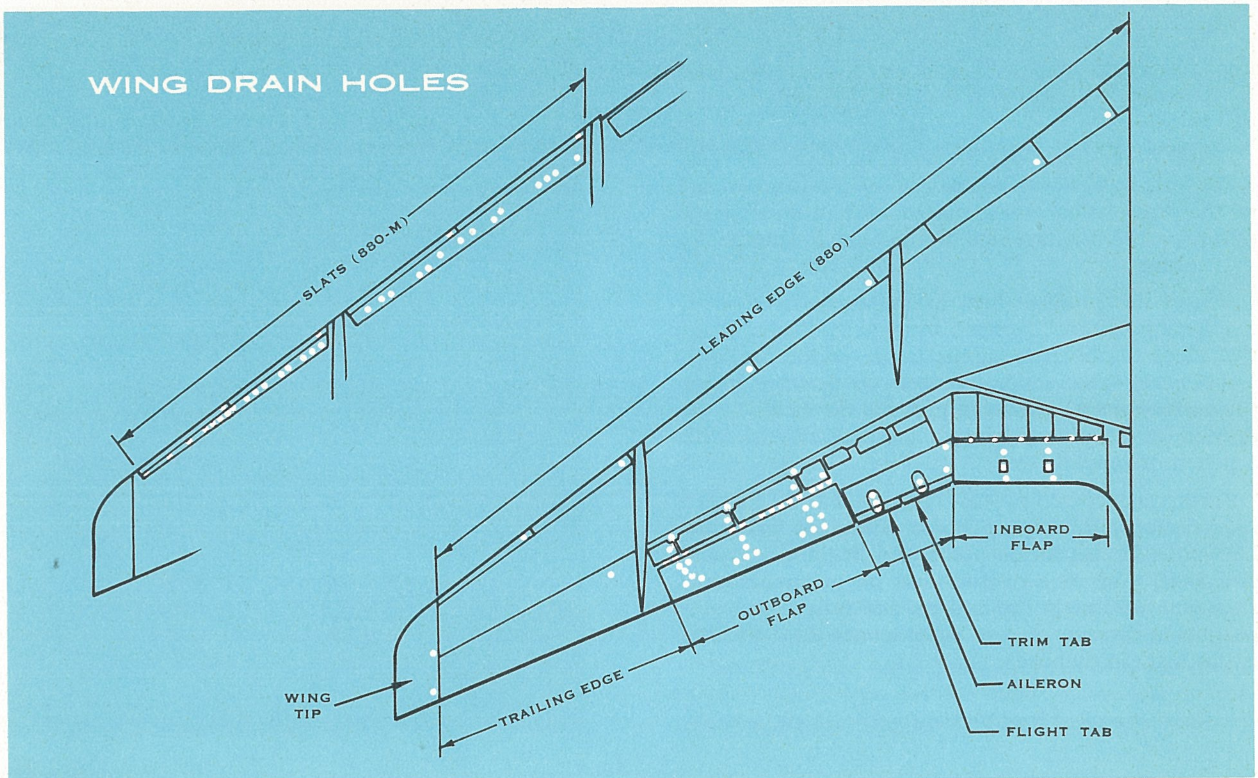
Along the fuselage keel in the pressurized area, the drain holes are equipped with spring-loaded plugs that close the holes from the inside of the fuselage. This check valve action prevents air leakage under pressurized conditions, yet permits the holes to be opened on the ground by a simple upward push with a pencil or screwdriver.

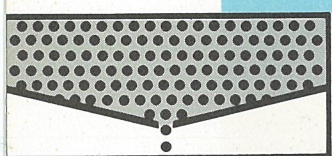
In the engine pod-pylons, icing is of little concern in areas of proximity to hot engines and exhausts. Low-point drains in the pylon and in the pod doors and keel, take care of fuel and oil accumulations. Low-point drains in the anti-ice and nose cowl compartments dispose of any water concentrations that might form in that area.

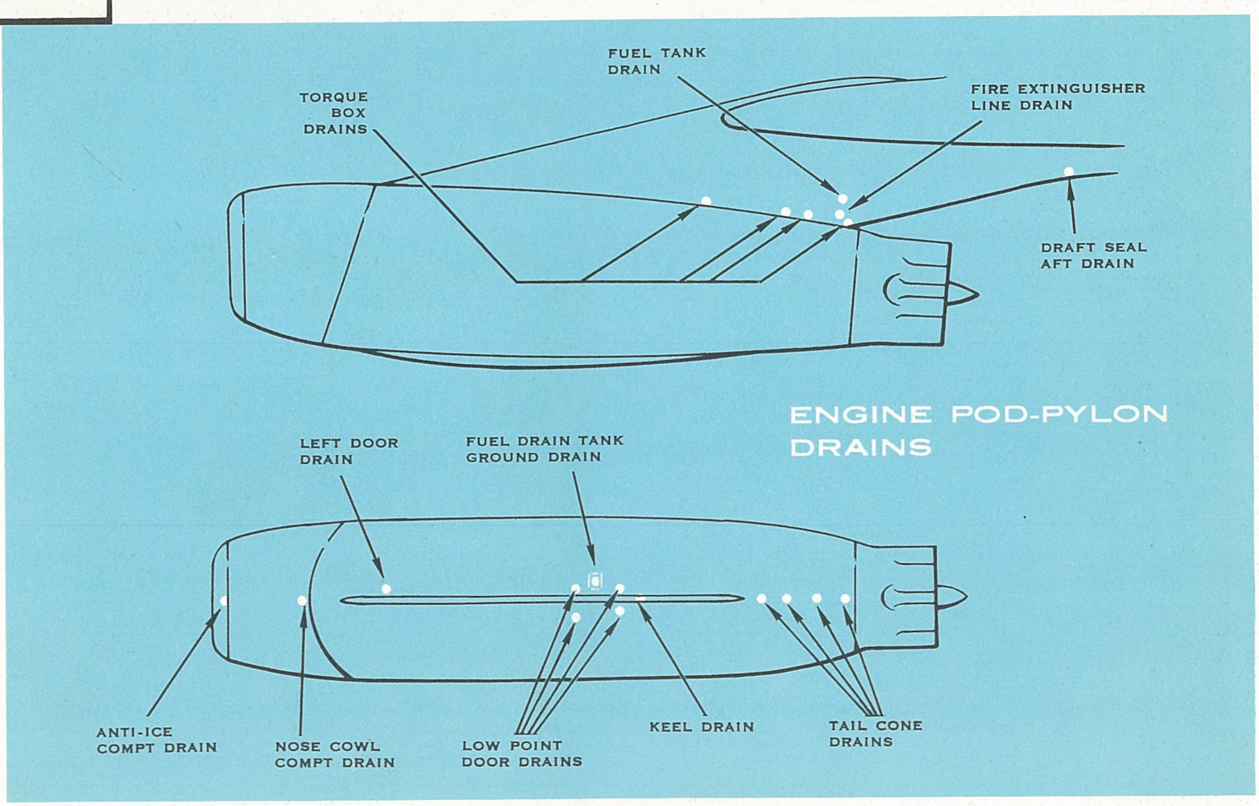
(See Wing and Pod/Pylon Drains on Page 8)



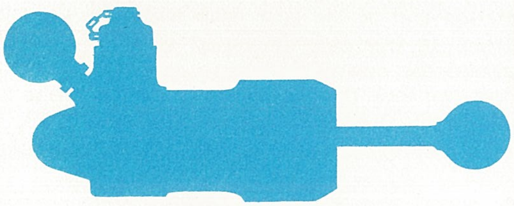



WING DRAIN HOLES
SLATS (880-M)
LEADING EDGE (880)
INBOARD FLAP
OUTBOARD FLAP
TRIM TAB
AILERON
FLIGHT TAB
WING TIP
TRAILING EDGE




FUEL TANK DRAIN
TORQUE BOX DRAINS
FIRE EXTINGUISHER LINE DRAIN
DRAFT SEAL AFT DRAIN
ENGINE POD-PYLON DRAINS
LEFT DOOR DRAIN
FUEL DRAIN TANK GROUND DRAIN
ANTI-ICE COMPT DRAIN
NOSE COWL COMPT DRAIN
LOW POINT DOOR DRAINS
KEEL DRAIN
TAIL CONE DRAINS

LIQUID SPRING



880 Nose Landing Gear

LIQUIDS ARE INCOMPRESSIBLE, or at least it is safe to assume so, in analyzing the operation of most hydraulic mechanisms. Landing gear air-oil shock struts depend primarily on compressing the air for the cushioning, or spring, action. Even under the 3000-psi pressure of the Convair 880 hydraulic systems, compression of the fluid is so minute that it is usually ignored.

One device in the "880" landing gear depends on the fact that, at much higher pressures, fluid is more compressible than is commonly realized. The device is the liquid spring in the nose gear, at the top of the right-hand upper drag brace. It is a small cylinder, approximately two inches in diameter and five inches long, with an attached dial pressure gage. The spring is mounted between the drag brace and the downlock arm. It functions as a shock absorber and also as a compression spring in the downlock linkage.

The liquid spring is essentially a cylinder with a piston, filled with hydraulic fluid of the type used in the landing gear struts. The cylinder is closed at one end, and all air is carefully bled out. Operating pressures are surprisingly high; in the "880," the cylinder is charged to 20,000 psi, and pressure rises to 40,000 psi at full compression. Gas under such pressure is potentially explosive. In this cylinder, however, the pressure is confined to less than three cubic inches of fluid. If the cylinder were to rupture, there would only be a spurt of fluid, and loss of the first tablespoonful would drop the pressure to zero.

In the liquid spring, the word "piston" must be carefully defined. The piston in this spring is the 5/16-inch-diameter rod that extends from the cylinder. Within the cylinder, at the end of the rod, is a piston head . . . the piston in the usual actuator. The piston head has a 1/16-inch orifice. As the spring is compressed, the fluid flows through the orifice. The liquid is compressed as the rod is forced into the cylinder. Since pressure equalizes on both sides of the piston head, the effective compressive force is proportional to the cross-sectional area of the rod.

The compression curves of the liquid spring show about 10% compression at 20,000 psi, and 16% at 40,000 psi. The 6% differential is created by forcing less than two inches of the 5/16-inch piston into the cylinder. Not all of the spring action is from compression of the liquid; some is from elastic expansion of the steel cylinder, and some from compression of the gland that seals the piston.

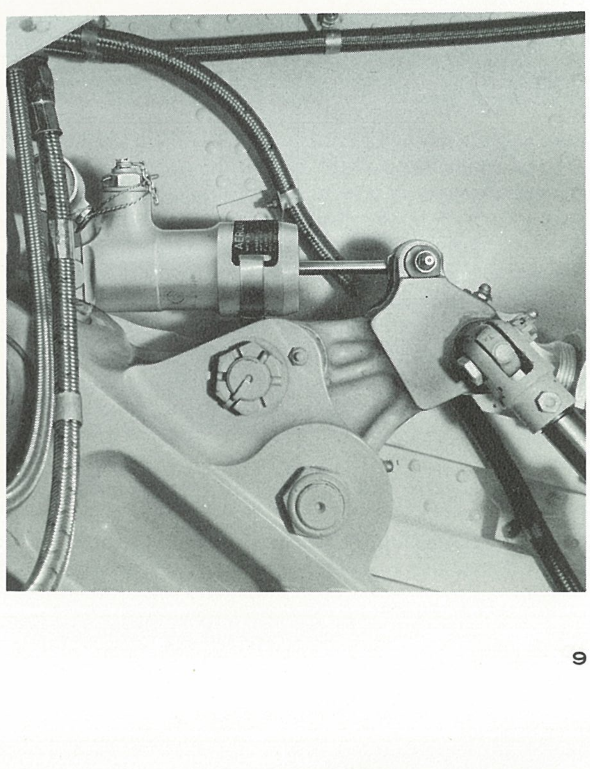
Simple calculations will show that the 5/16-inch-diameter piston has an area of .076 square inch, and that at 20,000 psi a force of approximately 1500 lb will be needed to start compressing the spring. At full compression, with internal pressure at 40,000 psi, the spring exerts an extension force of 3000 lb.

Successful operation of a liquid spring obviously depends on design of a gland able to withstand exceedingly high pressure. The gland assembly in the "880" spring comprises a steel pressure plate, into which six 3/32nd-inch dowel pins are held by a press fit; a Teflon bushing surrounded by a synthetic rubber ring; and a backing plate. The dowels pass through the rubber ring and into holes in the backing plate.

The area of the pressure plate surface that bears on the Teflon-and-rubber gland is less, by the total cross-sectional area of the dowel pins, than the pressure area on the liquid side of the pressure plate. The pressure exerted on the gland is actually greater than the internal liquid pressure.

The sealing pressure around the piston is correspondingly large. The peculiar qualities of Teflon, however, include the fact that against steel it has the lowest coefficient of friction of any substance known. The piston will slide through the bushing in spite of the pressure.

Some advantages of the liquid spring are now apparent. First, it has a very strong spring force. It can absorb, and deliver, a large quantity of energy in a short stroke, as in the "880" installation. Second, it can be utilized for shock absorption; the piston head with its orifice functions exactly like a standard hydraulic snubber. Third, it is self-damping. A coil spring, if compressed and suddenly released, will deliver its stored energy in a single impact. The shock-absorber design of the liquid spring damps its own action.

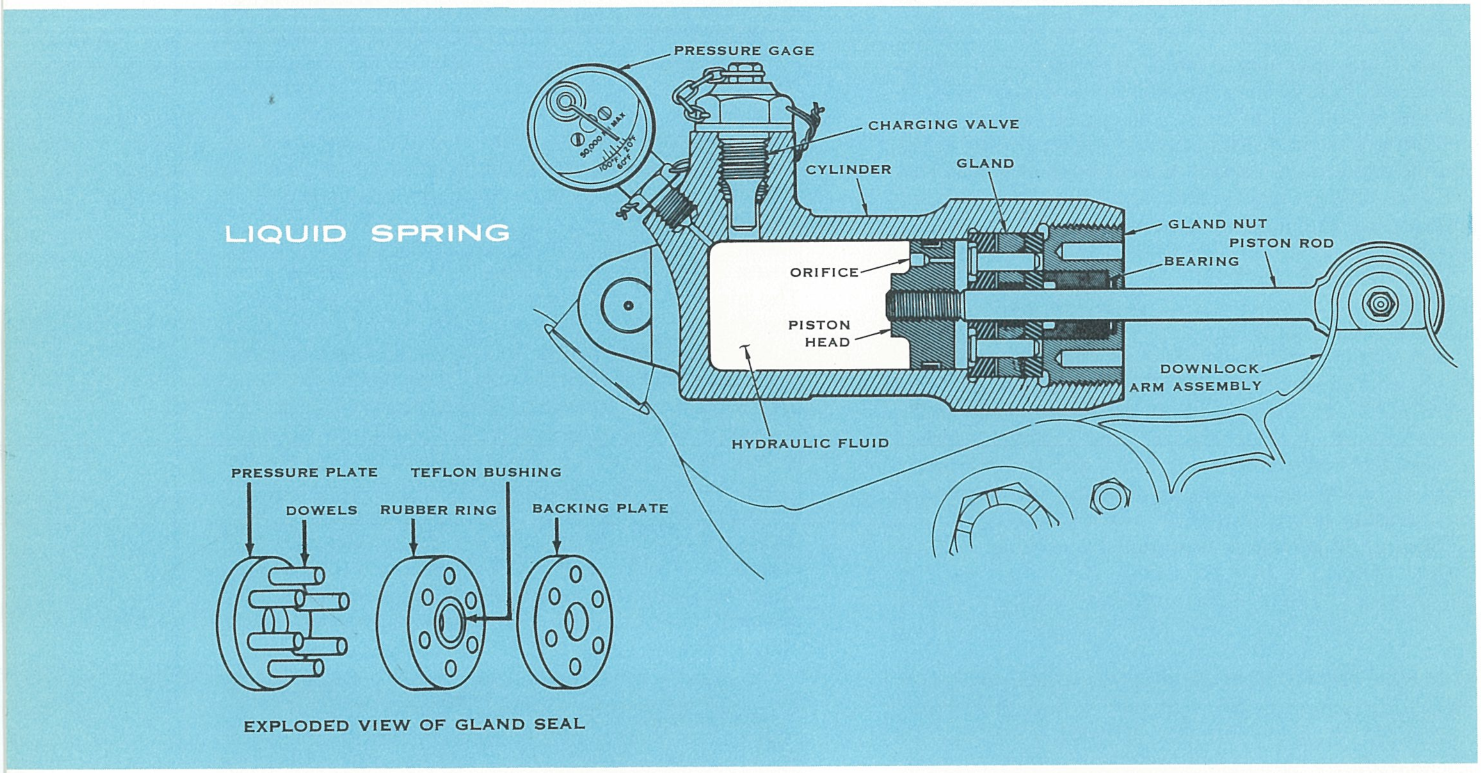


Although liquid springs have been used in military aircraft and missile applications, and in fact serve as main shock struts in one century-series aircraft, the "880" is believed to be the first civil aircraft to make use of one. In the "880," it serves two purposes: it supplants the bungee springs usually necessary to absorb the shocks associated with hydraulic actuator extension and retraction; and it takes up lost motion during emergency free fall so that the gear will lock down properly.

A "lost motion" mechanism was designed into the "880" downlock. Operation of this mechanism and the liquid spring function can best be explained by the accompanying schematic illustrations, which begin with the gear down, and show several stages during gear cycling. The lost motion device, necessary to allow the actuator to unlock the gear before retraction, is a pin-and-slot feature that allows the downlock arm to rotate far enough to release the downlock. A second element in the downlock linkage is the telescoping action of the downlock rod (sometimes called the "trombone rod"). The telescoping is necessary to prevent excessive pressure on the downlock lever as the gear approaches extended position.

Liquid spring stroke is less than 1¾ inches, limited by length of travel of the lost-motion action of the downlock arm. It is compressed whenever the downlock arm is in "unlock" position, which will be: 1) during retraction; 2) after retraction, until hydraulic pressure is removed from the actuator (neutral position of the pilot's landing gear lever); 3) during the first part of the extension cycle, in either normal or emergency operation. During extension, even with hydraulic power on, the actuator serves primarily as a snubber at first, preventing gear weight and air pressure from forcing the gear down too fast. This snubbing force compresses the spring. In normal (powered) extension, the liquid spring functions as a dashpot, absorbing the shock of the lost motion operation and of the gear drop when the uplock is released. In free fall, the liquid spring is necessary to return the downlock arm to its locking position. It does not lock the gear down; it positions the arm to allow the downlock rod to telescope. Then, the downlock spring can pull the locking lever into place, without having to bottom the actuator piston.

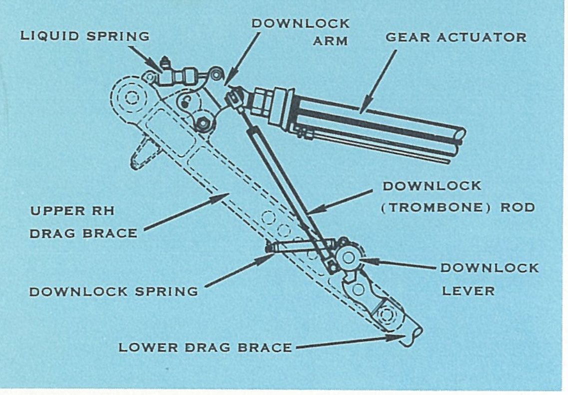
As stated, the liquid spring has a precharge that requires a 1500-lb. force to overcome. The linkage is so designed that at extreme extension of the spring (locking position of the lost motion), the spring is compressed slightly, preloading the downlock arm to locking position. For this reason, the spring cannot be bench-charged and then installed; it must be installed and then charged. Servicing the spring thus requires a portable charging gun — a special hand-operated tool resembling the ordinary grease gun.



The pressure gage dial reads in degrees Fahrenheit. The cylinder should be pressurized until the temperature reading matches ambient temperature. The spring has a considerable margin of force over what is actually required in the linkage, so the spring need be repressurized only whenever the dial shows 0°, or whenever it reads 60° below ambient temperature, whichever is highest.

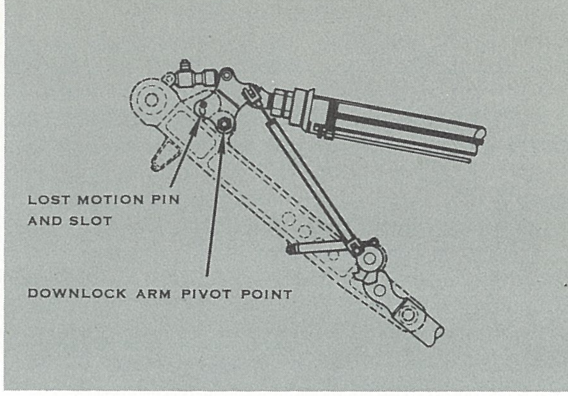
To improve sealing at the dial indicator, a Service Bulletin (32-30) has been issued to install a small rubber washer in the port between the cylinder and the foot of the gage.

GEAR DOWN AND LOCKED



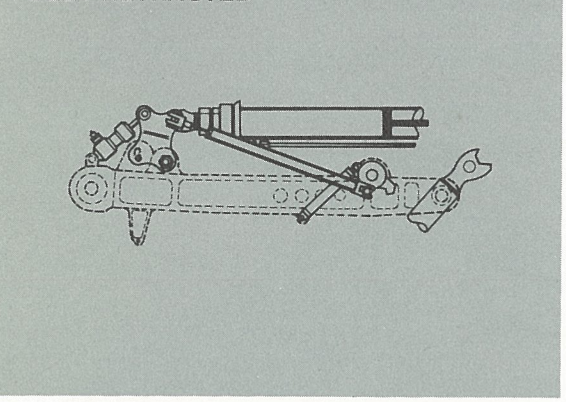
1 LIQUID SPRING IS EXTENDED; DOWNLOCK ARM IN LOCK POSITION; DOWNLOCK SPRING RETRACTED; DOWNLOCK ROD EXTENDED; LEVER LOCKS GEAR DOWN.

BEGINNING OF RETRACTION



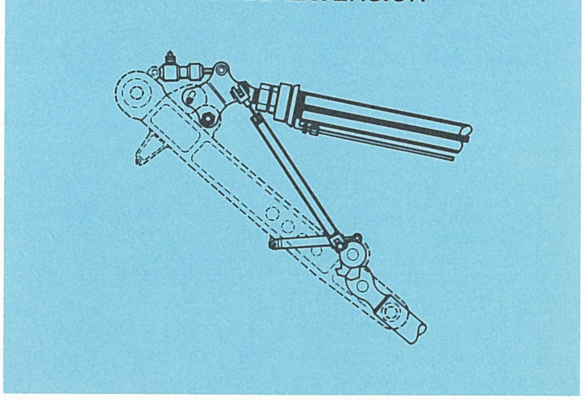
2 INITIAL ACTUATOR MOVEMENT ROTATES DOWNLOCK ARM THROUGH LOST MOTION, UNLOCKING DOWNLOCK. LIQUID SPRING IS COMPRESSED, DOWNLOCK SPRING IN TENSION.

FULLY RETRACTED



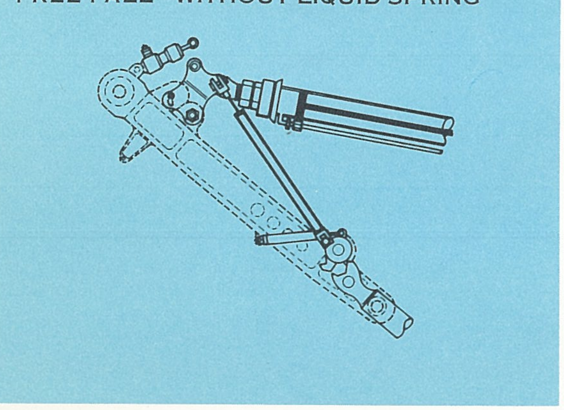
3 WITH GEAR FULLY RETRACTED AND PRESSURE IN ACTUATOR, LIQUID SPRING IS COMPRESSED. WHEN PRESSURE IS REMOVED FROM ACTUATOR, LIQUID SPRING EXTENDS.

NORMAL POWERED EXTENSION



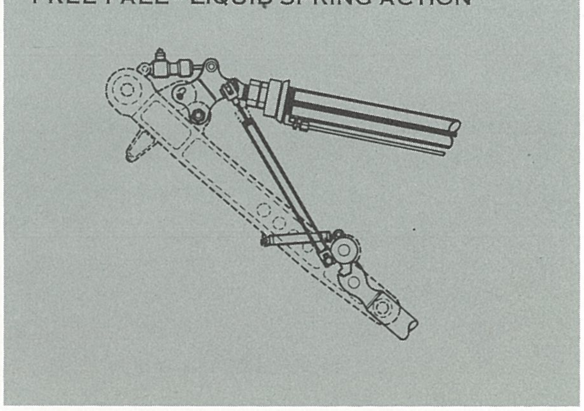
4 LIQUID SPRING ABSORBS SHOCK OF FALLING GEAR. WHEN ACTUATOR BOTTOMS, SPRING EXTENDS, DOWNLOCK ROD TELESCOPES; DOWNLOCK SPRING SNAPS DOWNLOCK INTO PLACE.

FREE FALL—WITHOUT LIQUID SPRING



5 ACTUATOR SNUBBING FORCE ACTS TO HOLD LOST MOTION ASSEMBLY IN UNLOCK POSITION. DOWNLOCK ROD DOES NOT TELESCOPE; DOWNLOCK SPRING PULL IS INSUFFICIENT TO BOTTOM ACTUATOR AND OPERATE DOWNLOCK.

FREE FALL—LIQUID SPRING ACTION



6 AFTER ABSORBING GEAR SHOCK, LIQUID SPRING HOLDS DOWNLOCK ARM IN DOWNLOCK POSITION, TELESCOPING DOWNLOCK ROD WHEN ACTUATOR BOTTOMS. DOWNLOCK SPRING CAN THEN SNAP DOWNLOCK INTO PLACE.

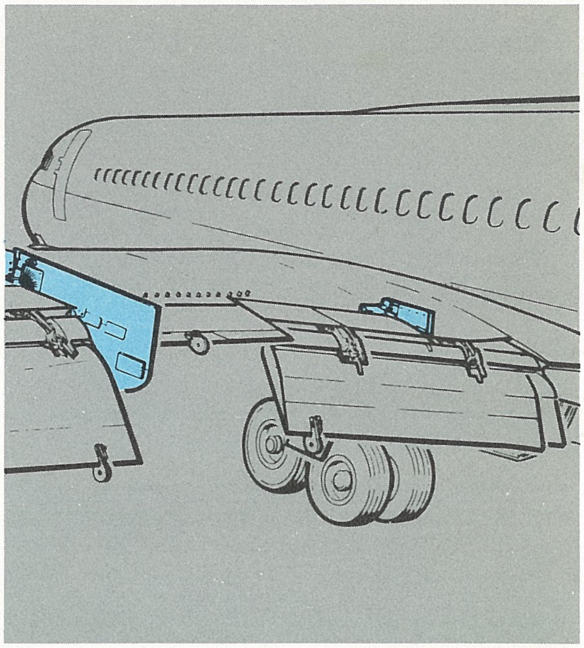
Spoiler Rigging Tools

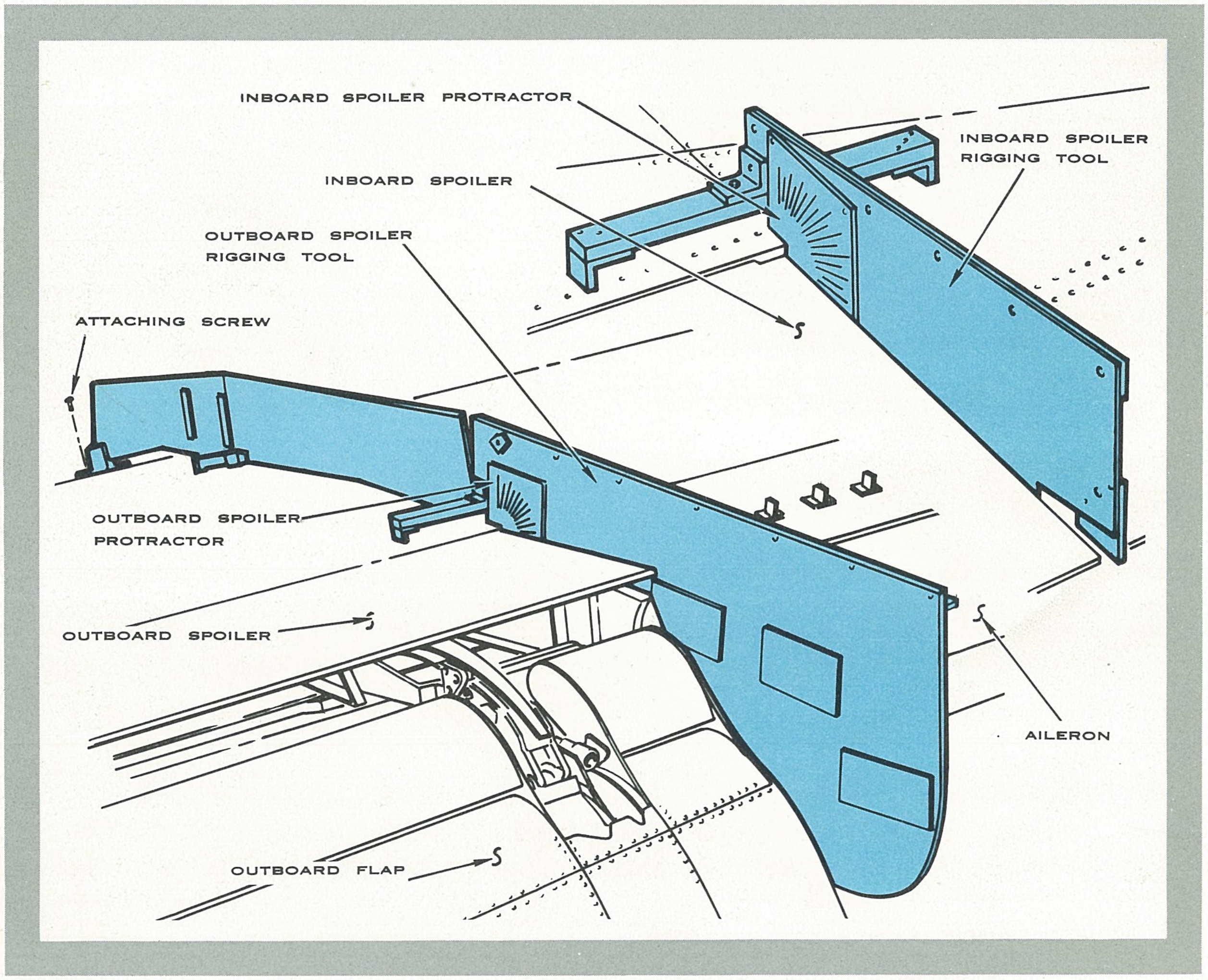
A SET OF FOUR SPOILER rigging tools are used on the Convair 880 production line for checking spoiler surface travel. These are tools 22-19007-901 and -902 for the left- and right-hand inboard spoilers; and 22-19006-901 and -902 for the left- and right-hand outboard spoilers. The locating fixture for the outboard spoilers is the same one that is used for rigging the aileron tabs except that a differently graduated plate is used (see March 1961 Traveler).

Each tool consists of two plates, contoured to fit the wing, with lugs at the lower edge for attachment. The lug, or dural bar, at the forward end of the fixture is used to support and help locate the tool. Screws on the upper surface of the wing are picked up for locating and mounting the fixture.

On each tool is mounted a protractor, graduated in degrees. When the fixture is properly positioned, the protractors are adjacent to the spoilers so that the protractor center is on the spoiler hinge center.

Deflections may be read directly by comparing the upper surface of the spoiler with the graduations on the protractor.





VOLUME XIII NUMBER 5 SEPTEMBER 1961

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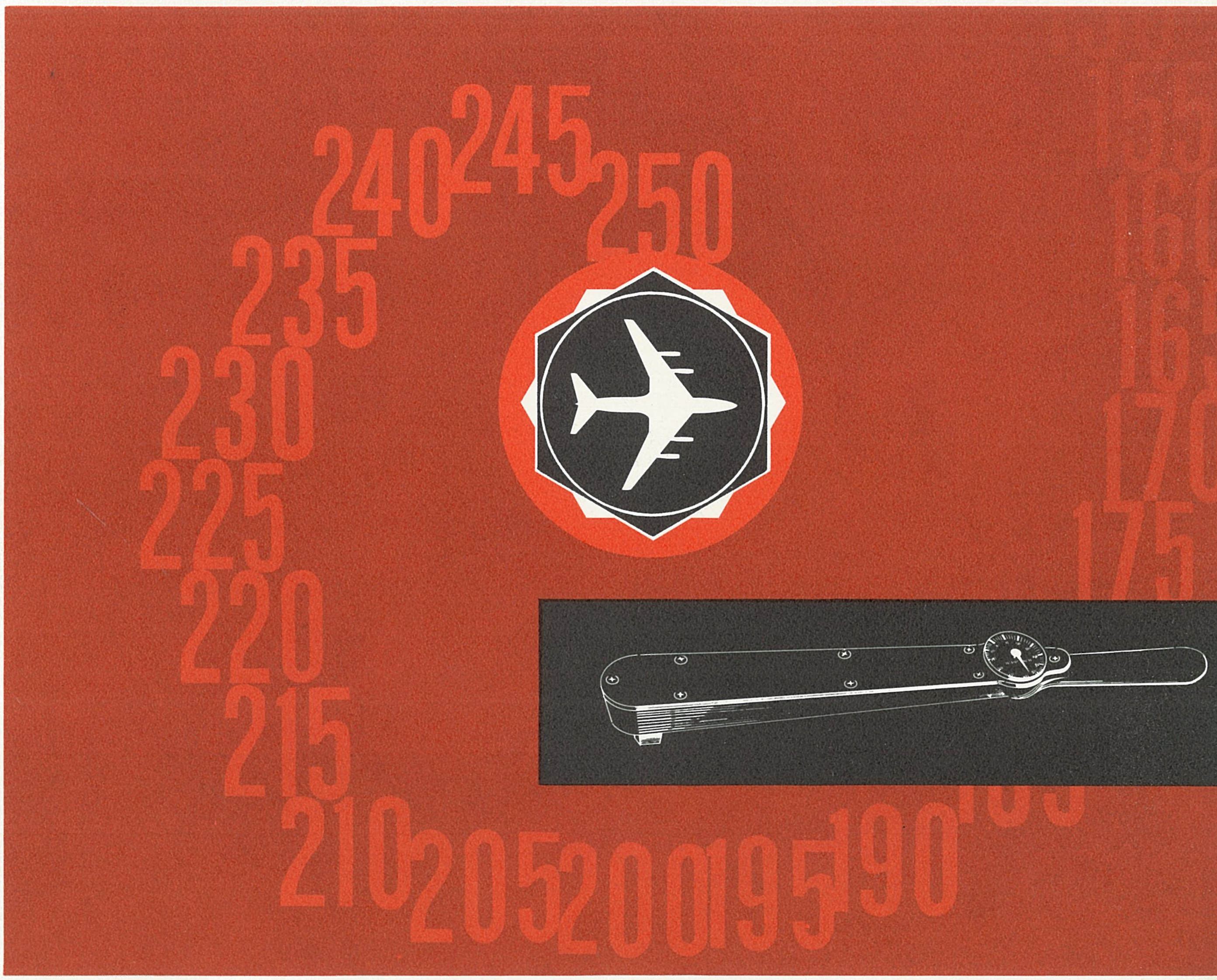
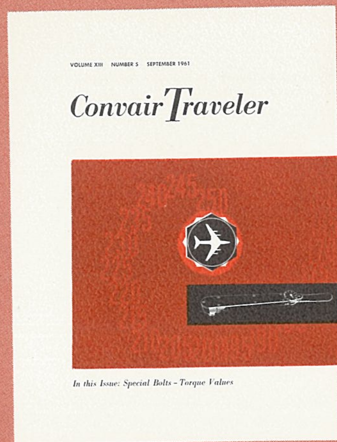


In this Issue: Special Bolts – Torque Values



OUR COVER

Cover artist George Paul had the difficult assignment of giving a clue to and illustrating the feature article in this issue. We hope you like his pleasing design.

Convair Traveler

VOLUME XIII NUMBER 5 SEPTEMBER 1961

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ART EDITOR — **A. R. THOMPSON**

IN THIS ISSUE

A digest of operation and service published monthly by the Service Publications Sections of Convair Customer Service Department in the interest of Convair operators. Communications should be addressed to the Manager of Customer Service Department, Convair, San Diego 12, California. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without specific approval of their cognizant organization.

GENERAL DYNAMICS | CONVAIR

SPECIAL BOLTS • TORQUE VALUES

A NUMBER OF SPECIAL BOLTS are used on Convair 880's. They are special because their design and usage have been dictated by requirements somewhat outside the range of standard bolt adaptability.

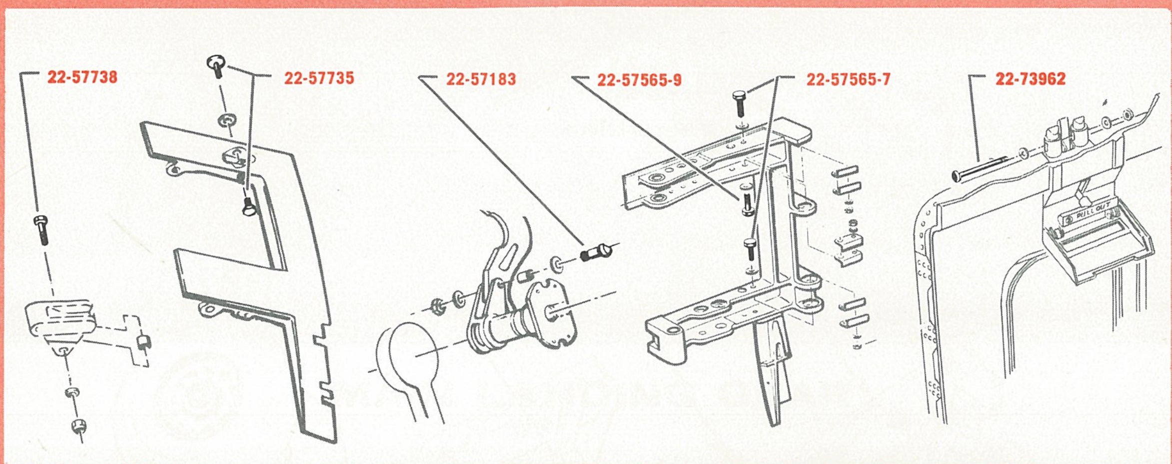
The familiar AN, NAS, and MS standard bolts are quite extensively used where the advantages of established strength and standardization are most practical. The torque values used for tightening the nuts on these bolts have been standardized, and tables containing these values are readily obtainable.

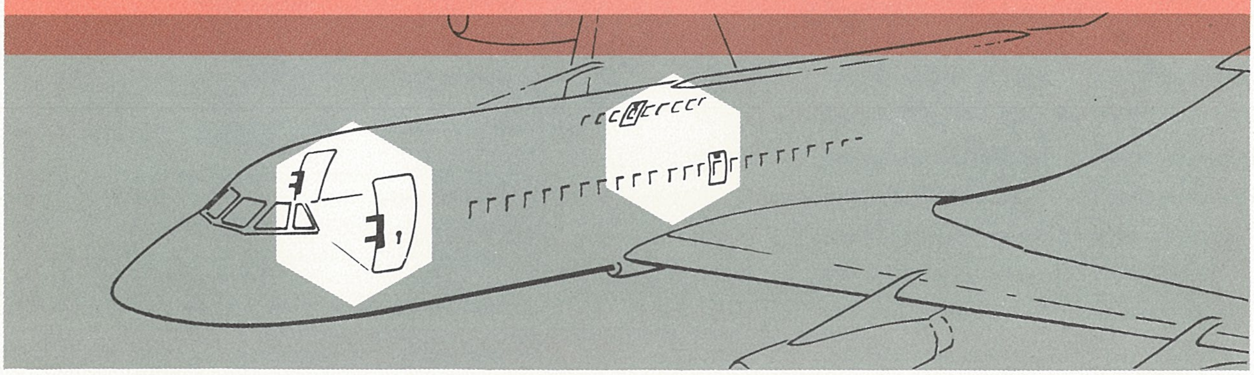
The accompanying charts show many of the special bolts used on the Convair 880, their locations, and torque requirements. In some instances, minor changes or modifications have been made to standard bolts, and given a Convair drawing number. These reworked (special) bolts then require a special torque value.

During maintenance and overhaul operations, manuals should be checked to be sure that latest configuration bolts and installation procedures are used.

DOORS AND EMERGENCY EXITS

PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-57183	Fwd M-E door latch mech housing assy fork attach.	60-85 inch-pounds
22-57735	Fwd M-E door hinge guide	20-25 inch-pounds
22-57565-7	Fwd service door upper hinge guide	20-25 inch-pounds
22-57565-9	Fwd service door lower hinge guide	20-25 inch-pounds
22-57738	Fwd M-E snubber attach.	20-25 inch-pounds
22-73962	Emergency exit door latch housing	Torque to shoulder of bolt

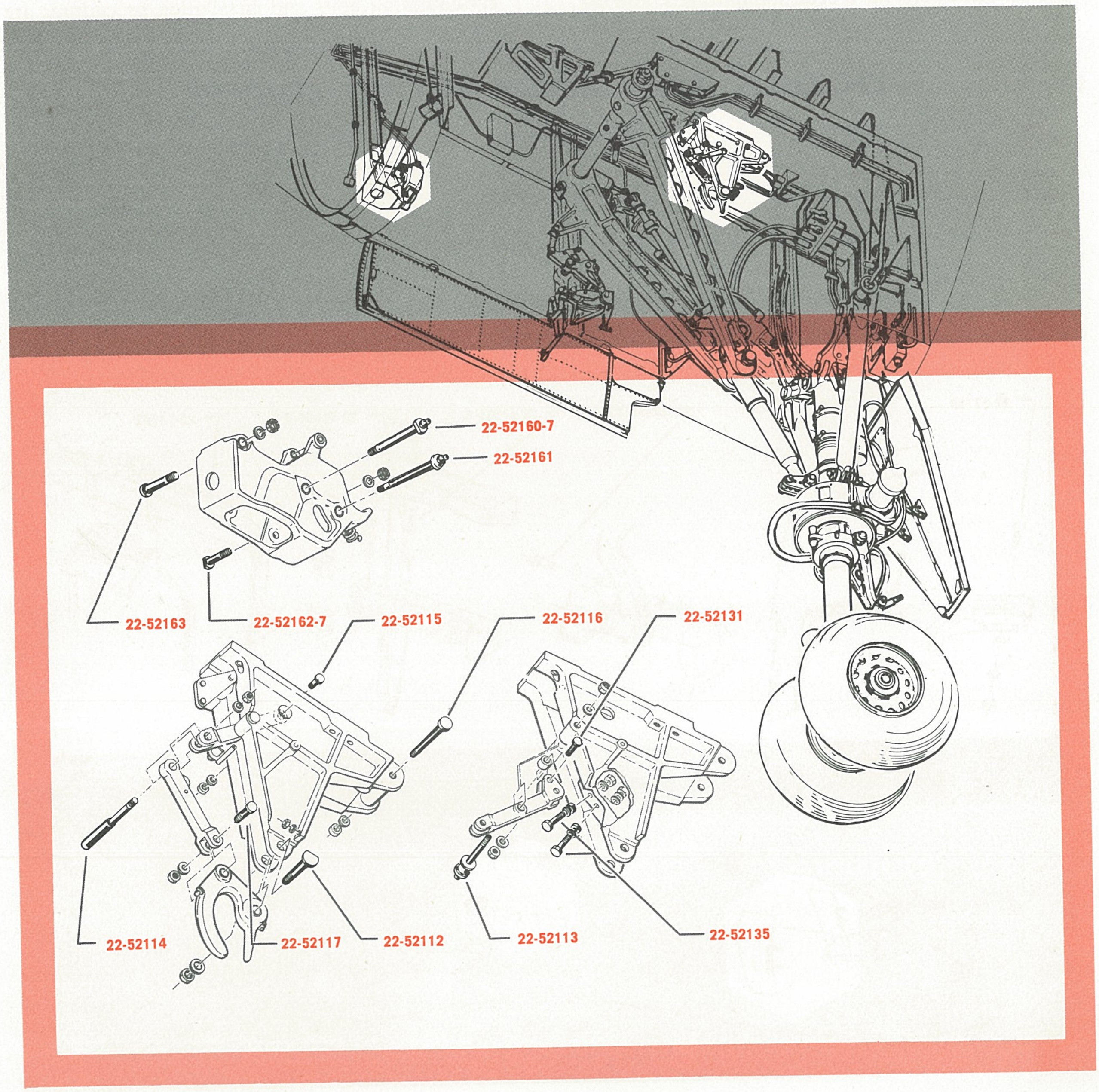


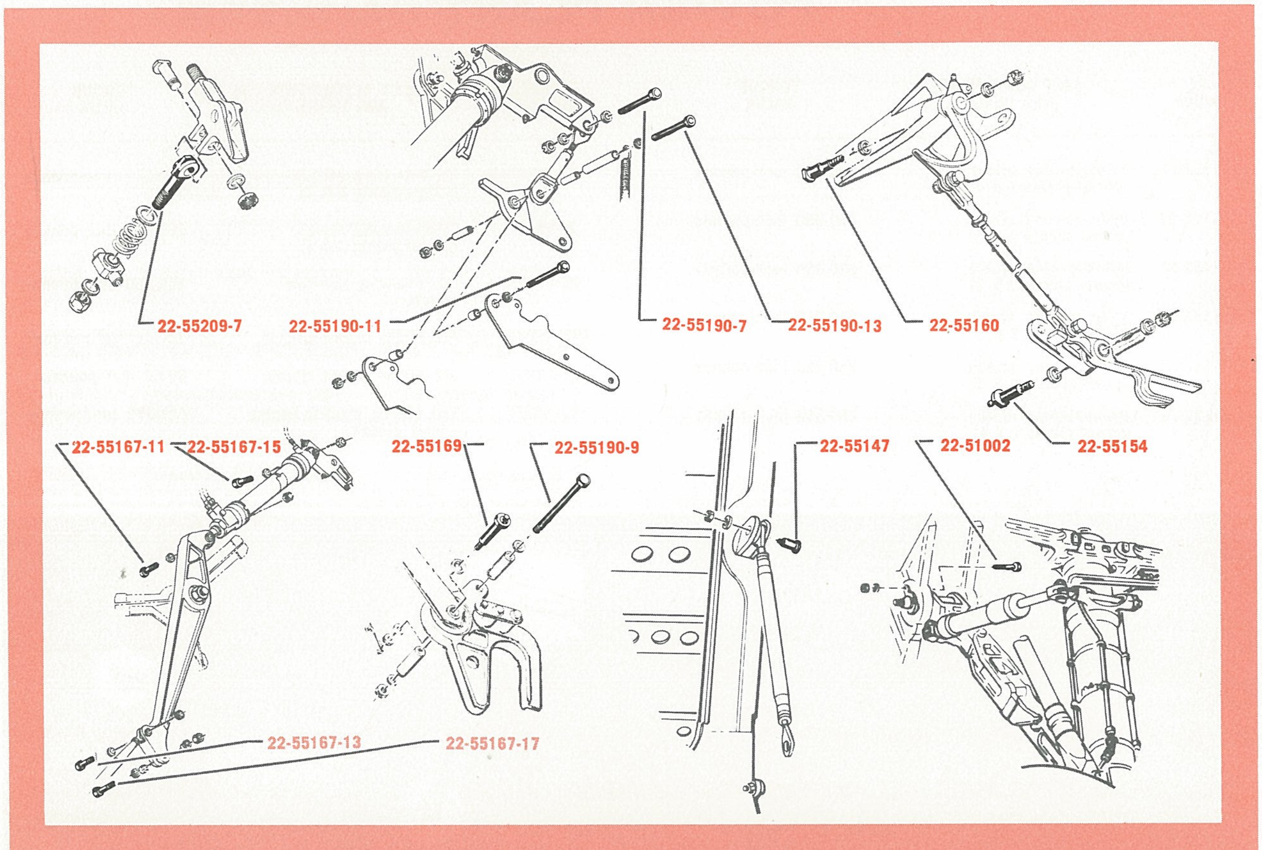


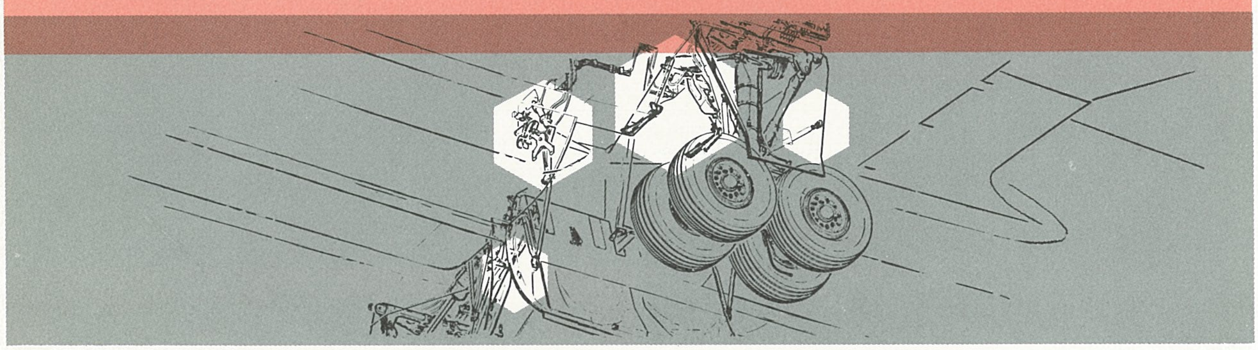
NOSE LANDING GEAR

PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-52112	Uplock hook-to-uplock assy pivot hook	Finger tight
22-52113	Uplock bellcrank pivot	Finger tight
22-52114	Uplock link attach.	Finger tight
22-52115	Uplock piston rod actuator	Finger tight
22-52116	Uplock actuator attach.	Finger tight
22-52117	Uplock link attach.	Finger tight

PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-52131	Uplock cable attach.	Finger tight
22-52135	Uplock adjustment	No special torque
22-52160-7	Door uplock hook assy	Finger tight
22-52161	Door uplock lever	Finger tight
22-52162-7	Door uplock cylinder	Finger tight
22-52163	Door latch-to-door uplock assy attach.	Finger tight







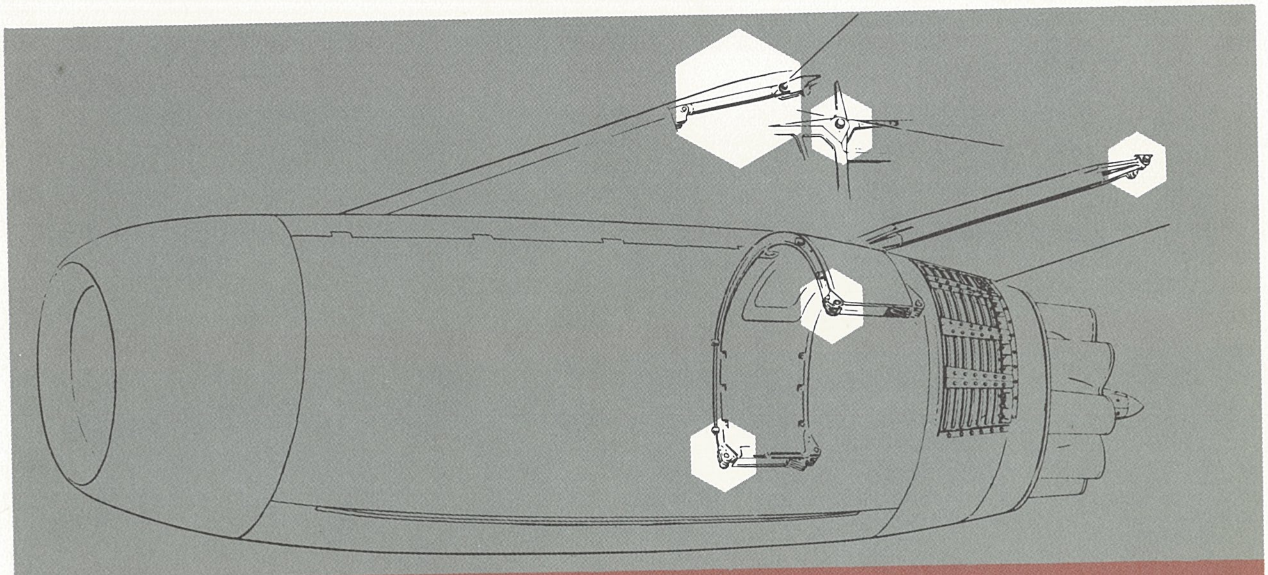
MAIN LANDING GEAR

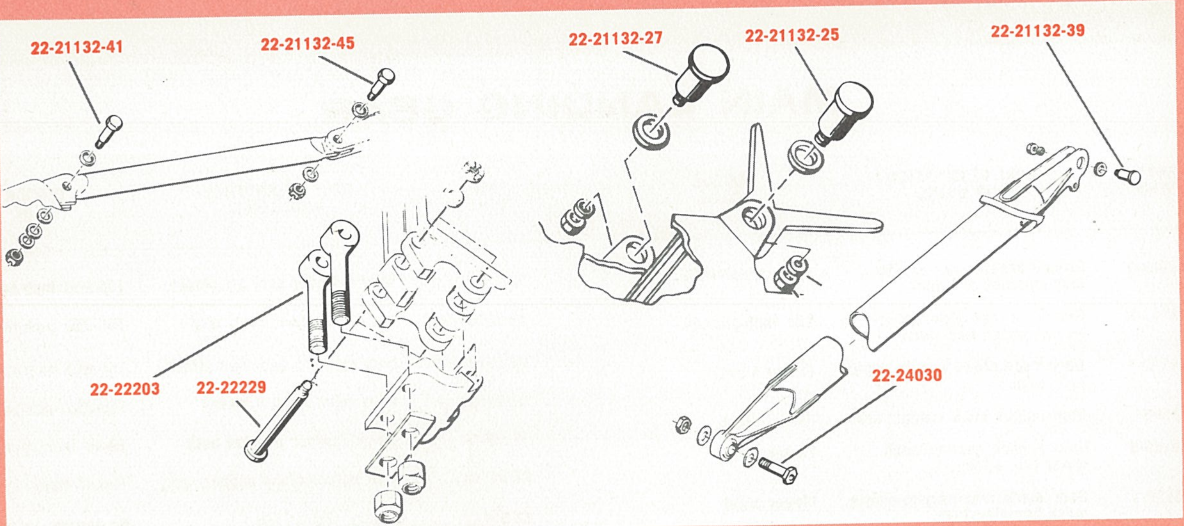
PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-55209-7	Ground access door arm-to-lock trunnion aft cinch	125 inch-pounds
22-55209-8	Ground access door arm-to-lock trunnion fwd cinch	125 inch-pounds
22-55190-7	Door mech crank assy to upper link attach.	Finger tight
22-55160	Door uplock hook support assy	Finger tight
22-55190-9	Uplock hook assy-to-mech lower link attach.	Finger tight
22-55190-11	Door mech arm assy-to-emerg mech trunnion brkt	Finger tight
22-66190-13	Door mech clevis-to-arm attach.	Finger tight

PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-55167-11	Door cylinder assy aft attach.	150-250 inch-pounds
22-55167-13	Door mech fwd crank assy	150-250 inch-pounds
22-55167-15	Door cylinder assy fwd attach.	150-250 inch-pounds
22-55167-17	Door mech aft crank assy	150-250 inch-pounds
22-55169	Uplock switch bracket assy	20-40 inch-pounds
22-55154	Door uplock crank support assy	Finger tight
22-55147	Fairing rod attach.	No special torque
22-51002	Upper side brace shaft	Limit torque to 25 inch pounds

POWER PLANT

PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-21132-25	Pylon-to-wing attach. (power plants 1 & 4)	250-350 inch-pounds
22-21132-27	Pylon-to-wing attach. (power plants 1 & 4)	250-350 inch-pounds
22-21132-33	Pylon-to-wing attach. (power plants 2 & 3)	250-350 inch-pounds
22-21132-35	Pylon-to-wing attach. (power plants 2 & 3)	250-350 inch-pounds
22-21132-37	Pylon-to-wing attach. (power plants 2 & 3)	250-350 inch-pounds
22-21132-39	Pylon-to-wing attach. (power plants 1 & 4)	250-350 inch-pounds
22-21132-43	Pylon-to-wing attach. (power plants 2 & 3)	250-350 inch-pounds
22-21132-45	Pylon-to-wing attach. (power plants 1 & 4)	250-350 inch-pounds
22-21132-41	Pylon-to-wing link-fwd attach.	250-350 inch-pounds
22-22203	Aft engine mount sling	92-108 foot-pounds
22-22229	Aft engine mount attach.	60-85 inch-pounds
22-24030	Tail fairing strut-to-engine mount attach.	184-275 foot-pounds



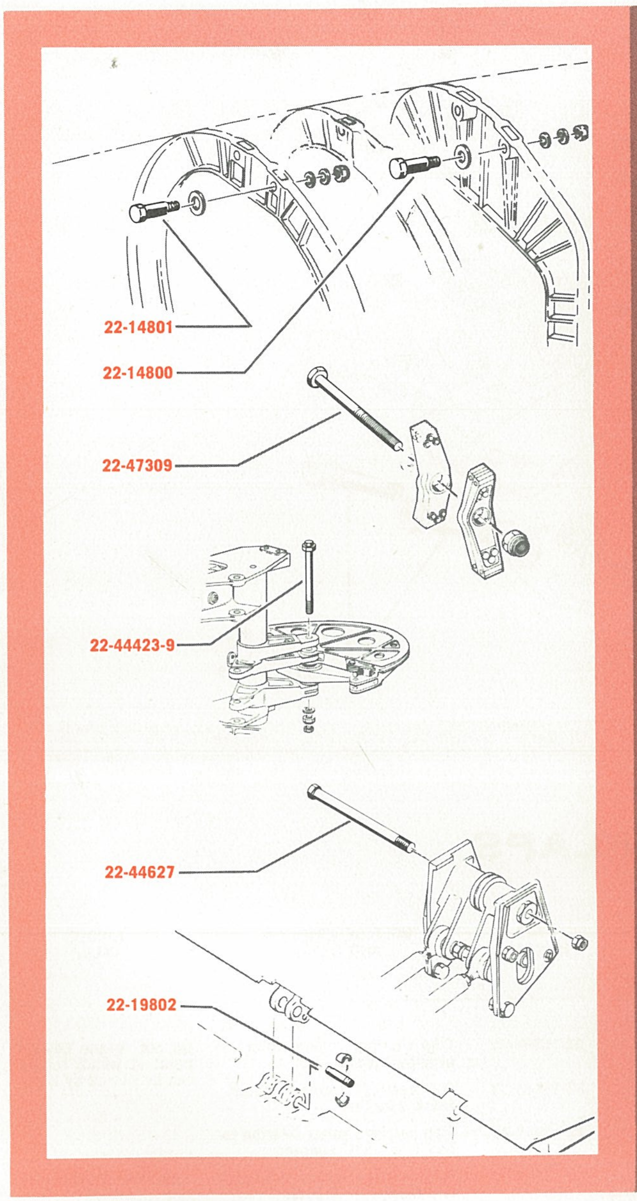


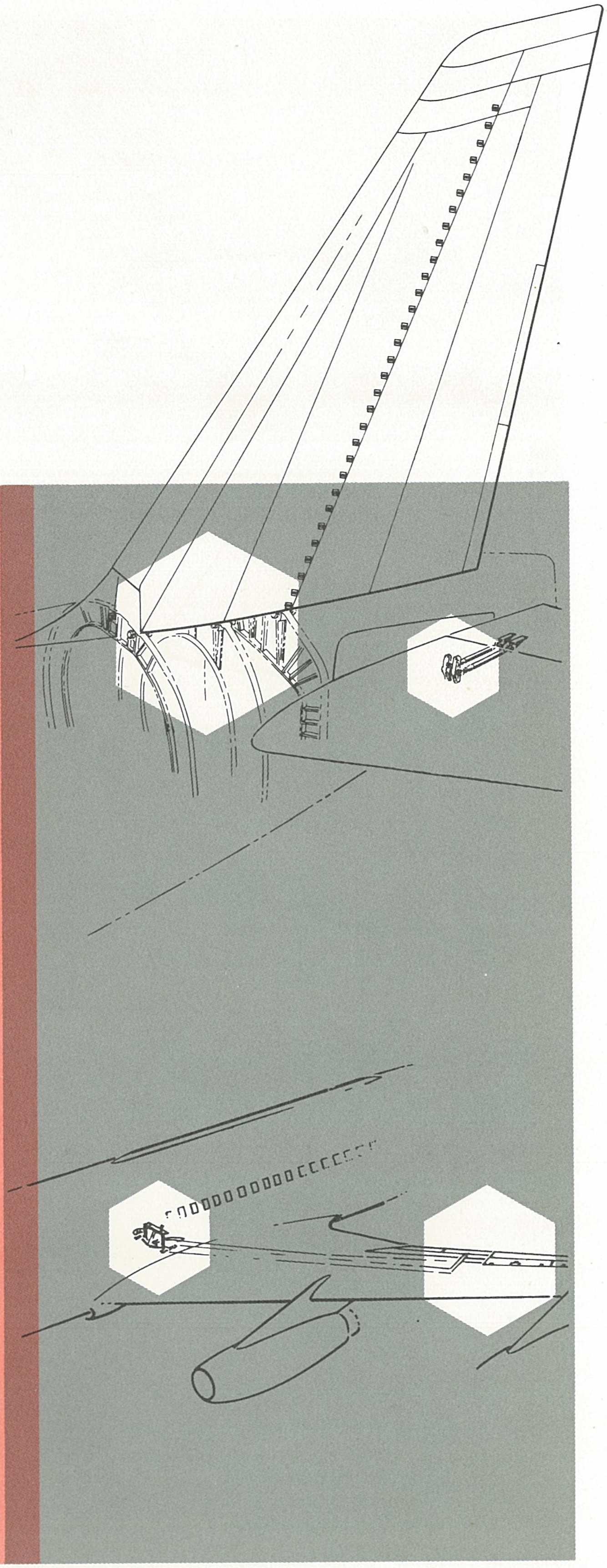
EMPENNAGE

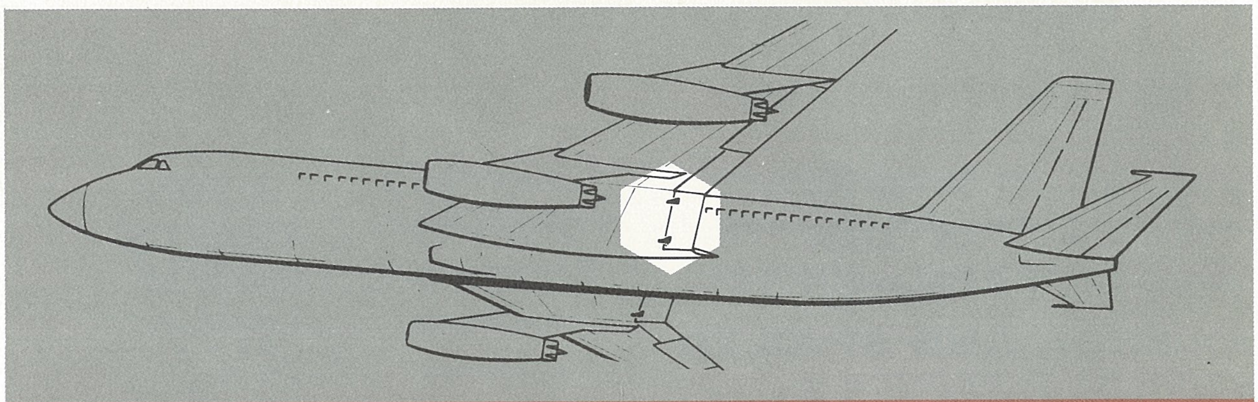
PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-14800	Vertical stabilizer-to-fuselage aft attach.	35-50 foot-pounds
22-14801	Vertical stabilizer-to-fuselage fwd attach.	35-50 foot-pounds
22-47309	Elevator flight tab support assy	No special torque

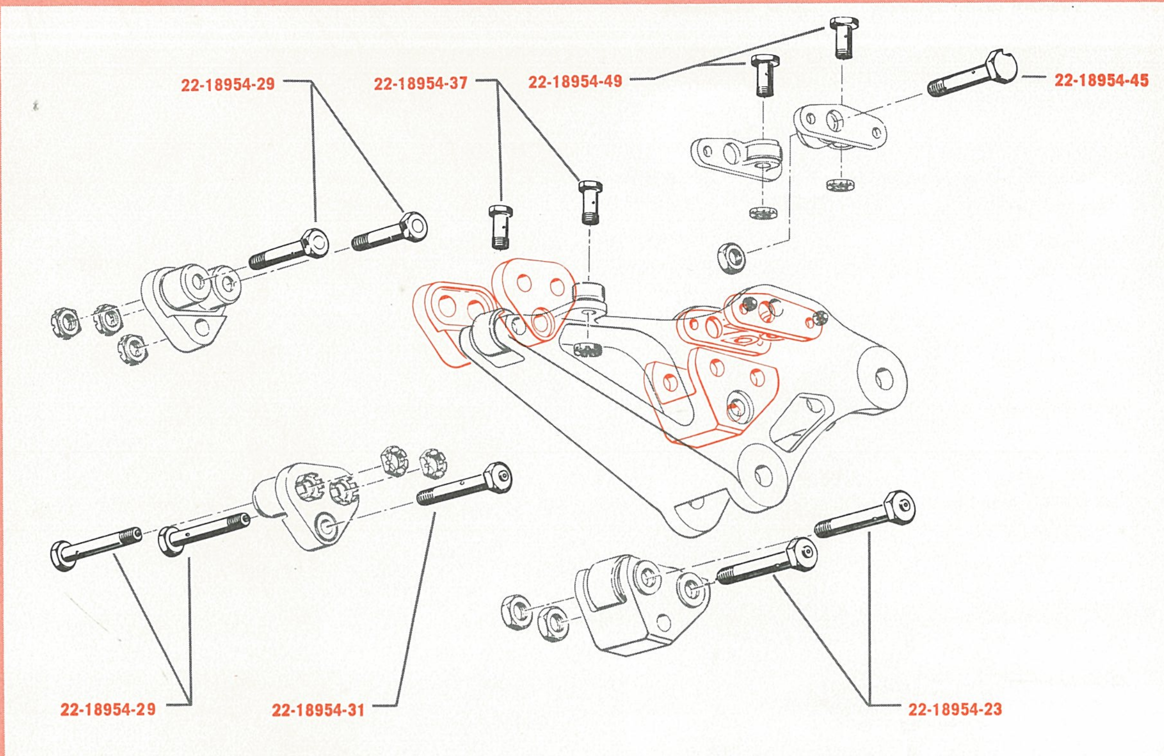
AILERON AND SPOILER

22-44423-9	Aileron flight & trim tab control	No special torque
22-44627	Aileron trim tab bellcrank	No special torque
22-19802	Outboard spoiler retaining	20-50 inch-pounds









WING FLAPS

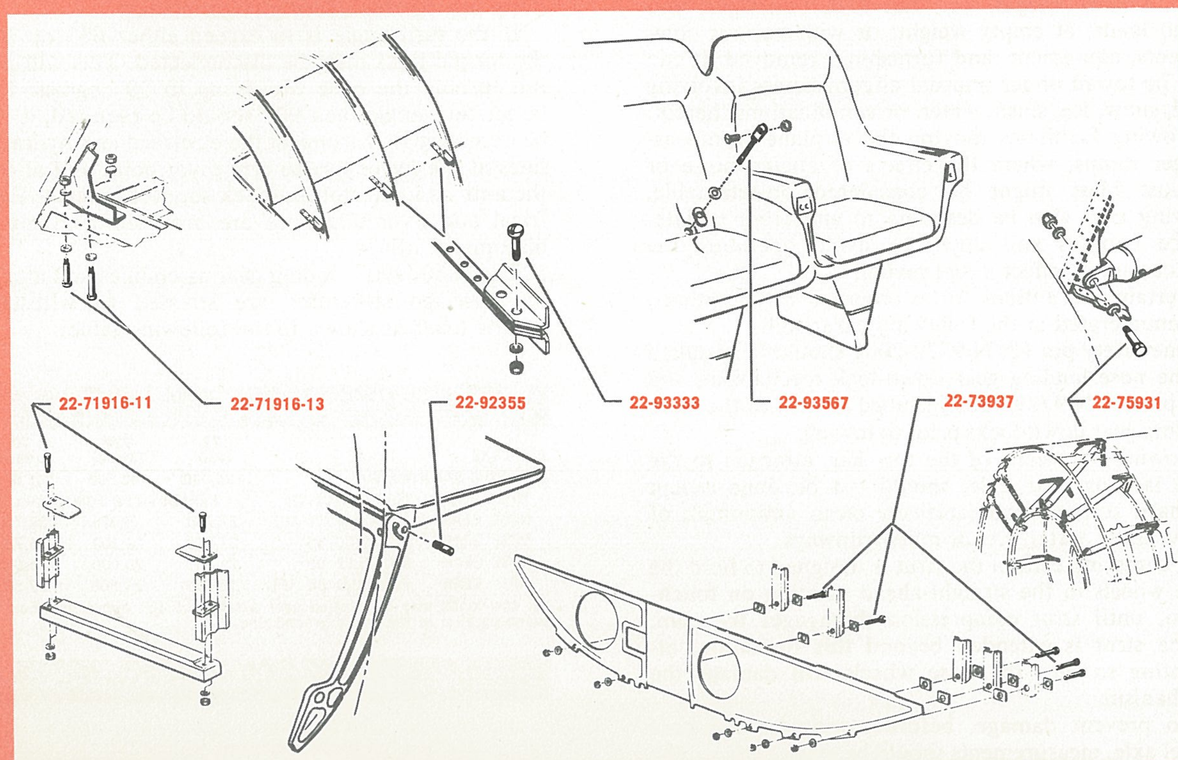
PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-18954-23	Flap carriage-to-FC aft truck adapter	Do not torque beyond point at which rollers can be turned by hand.
22-18954-29	Flap carriage-to-FC fwd truck adapter	
22-18954-49	Flap carriage to inbd FC frame	
22-18954-37	Flap carriage inbd frame assy	

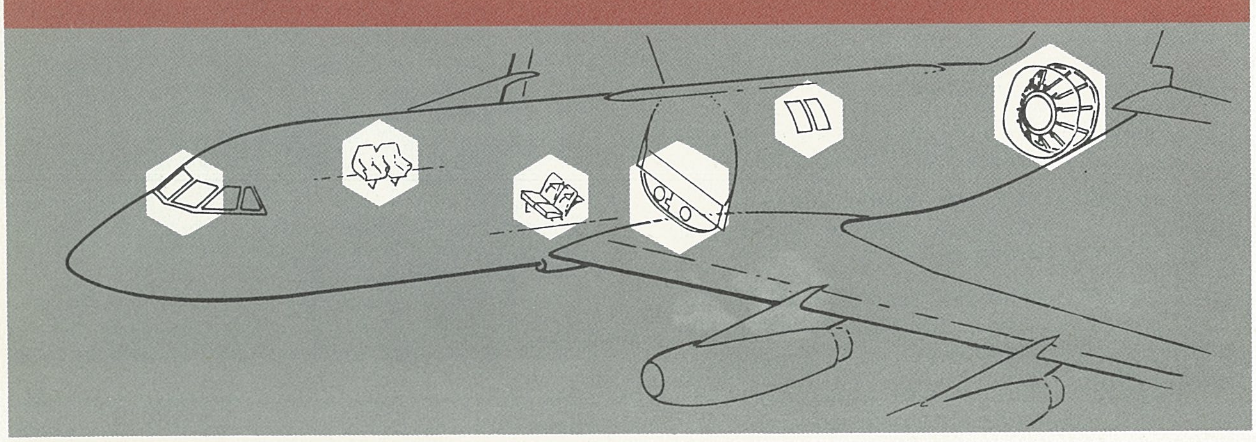
PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-18954-45	Flap carriage frame roller bearing attach.	Do not torque beyond point at which rollers can be turned by hand.
22-18954-33	Flap carriage frame to-FC-aft truck adapter	
22-18954-27	Flap carriage roller bearing-to-fwd truck half adapter.	
22-18954-31	Flap carriage frame to-FC-aft fwd truck half adapter	100-300 inch-pounds

MISCELLANEOUS BOLTS

PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-71916-11	Center windshield lower longeron ftg.	50-70 inch-pounds
22-71916-13	Center windshield LH corner ftg,-to-frame attach.	50-70 inch-pounds
22-71916-15	Center windshield RH corner ftg,-to-frame attach.	50-70 inch-pounds
22-92355	Food tray latch-to-support assy attach.	12-15 inch-pounds

PART NUMBER	BOLT DESCRIPTION AND USAGE	TORQUE VALUE
22-93333	Coat rack hanger bracket attach.	Torque to shoulder of bolt.
22-93567	Club compt double seat assy belt attach.	60-85 inch-pounds
22-73937	Lower underwing bulkhead-to-web attach.	50-70 inch-pounds
22-75931	Aft press. blkhd compression tube-to-adapter attach.	.010 min gap after torquing





TOWING CONVAIR 880/990 AIRCRAFT

TOWING THE CONVAIR 880/990 jet airliners is both a practical and economical means of moving the airplanes. Special provisions, designed into the aircraft, facilitate towing operations. The airplane may be towed at the forward end by a tow bar (P/N 22J-171) attached to the nose landing gear axle, or either forward or backward by means of cables attached to the forward end or to the aft end of the main landing gear axle beam assemblies.

The airplane may be towed under diversified conditions. It may be towed day or night, depending on the requirement. The airplane may be towed at maximum takeoff weight, i.e., full fuel, passenger, and cargo loads; at empty weight; or with various components, equipment, and furnishings removed. It can also be towed under unusual circumstances involving mud, snow, ice, slush, water, or combinations thereof.

Towing facilitates moving the airplane from passenger ramps, where the effects of engine noise or exhaust blast might be considered objectionable. Towing may also be desirable to and from maintenance hangars and docks to avoid operating the engines and to effect a fuel saving.

Certain precautions to be observed in operations, are enumerated in the following paragraphs.

One safety pin (P/N 9772-200) should be installed in the nose landing gear down-lock mechanism, and one pin (P/N 9729-150) installed in each of the main landing gear down-locks prior to towing.

Towing by means of the tow bar, attached to the nose landing gear axle, should not be done except on hard surface, comparatively clean (minimum of snow, slush, water, ice, or mud) runways.

A centering cam in the strut is designed to hold the nose wheels in the straight-ahead position on touchdown, until strut compression disengages the cam. If the strut is extended beyond this limitation, attempting to turn the nose wheels will damage the mechanism.

To prevent damage, before towing by the nose wheel axle, measurements should be made between the upper and lower torque arm pin centers. The following pin center measurements will clarify the various strut positions:

OPERATING RANGE

- 4.925″ — Nose strut when fully compressed.
- 6.000″ — Strut may be rotated 360° and be within 1.075″ from bottoming.
- 14.000″ — This dimension allows .925″ clearance between upper and lower cam faces.
- 14.925″ — This dimension allows the upper cam to just clear the top of the lower cam.
- 17.925″ — Strut is fully extended (13.00″ being the normal stroke).

The airplane should not be towed when the nose landing gear strut is extended more than 14.00 inches, or compressed to less than 6.00 inches when the nose wheels are in contact with the runway surface.

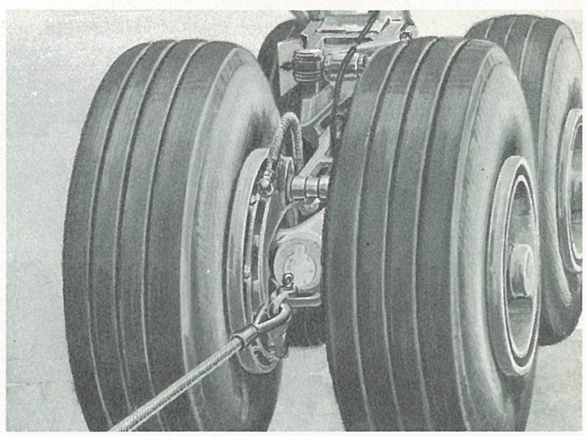
Towing at the nose landing gear without disconnecting the torque arms is permissible if the following requirements are adhered to: 1) angle of turn should be limited so that steering cylinder does not bottom (70° on "880" and "880M"; 63° on "990"); 2) rate of turn should be kept slow; 3) no attempt should be made to touch or turn the steering wheel in the cockpit. Failure to observe these precautions can seriously damage the steering mechanism.

If the turn angle is to exceed either 63° or 70°, the torque links must be disconnected. This will permit turning the nose wheels up to 90 degrees. If a larger turn angle than 90° should be required, it will be necessary to disconnect the electrical and hydraulic lines at the lower torque arm pivot point and also at the anti-skid detector and jack support bracket. Electrical and hydraulic lines are provided with quick-disconnect fittings.

The "880/990" landing gear assemblies and attaching fuselage structures are stressed to withstand towing loads as shown in the following table:

AIRPLANE		22 (880)	22M (880M)	30 (990)
MAXIMUM RAMP WEIGHT		185,000	193,500	245,000
TOW POINT	TOW DIRECTION	PERMISSIBLE TOW LOADS		
NOSE GEAR	FORWARD OR AFT	27,750	29,025	36,750
NOSE GEAR	SWIVELED 45°	27,750	28,300	36,750
NOSE GEAR	SWIVELED 90°	20,000	20,000	26,000
MAIN GEAR	FORWARD OR AFT	20,800	21,800	27,500

All tow loads may be applied over a range of 10° above or below the plane parallel to the static ground line.



Airplane can be towed either forward or aft by cables attached to tow lugs at forward and aft ends of truck.

If rough terrain or runway surfaces impose a stress beyond the limitations for nose gear towing, the airplane should be towed at the main landing gear. When towing by cables attached to the main landing gear axle beam, the cables should be rigged with a shear pin safety feature (NAS 146 shear bolt), and additionally secured to prevent whipping in the event of cable breakage, or shear.

When towing either forward or backward by means of cables attached to the main landing gear, caution should be exercised to be sure that the airplane is not turned at an angle where the cables will come in contact with the main landing gear tires. The airplane may be turned at an angle of 50° before scuffing of the main landing gear tires will occur. While fluid leakage caused by ovalization of the struts under torsional loads has never been reported in service, it is considered to be good practice to roll the airplane several feet in the straight fore or aft direction on completion of a turn before parking for maintenance or passenger service.

The airplane brakes should be in good operating condition at all times during towing operations. Although a feature of the hydraulic system will allow two or three brake applications for approximately one hour after engine shut down, this feature should not be considered as affording adequate braking during towing. Emergency pneumatic braking, at any time, will necessitate bleeding of the hydraulic system.

The aircraft brakes should be manned at all times during towing operations. Communication should be maintained between the towing tug operator (s) and the man in the flight compartment at all times. Each man should be equipped with a microphone and headset, or a combination microphone/headset.

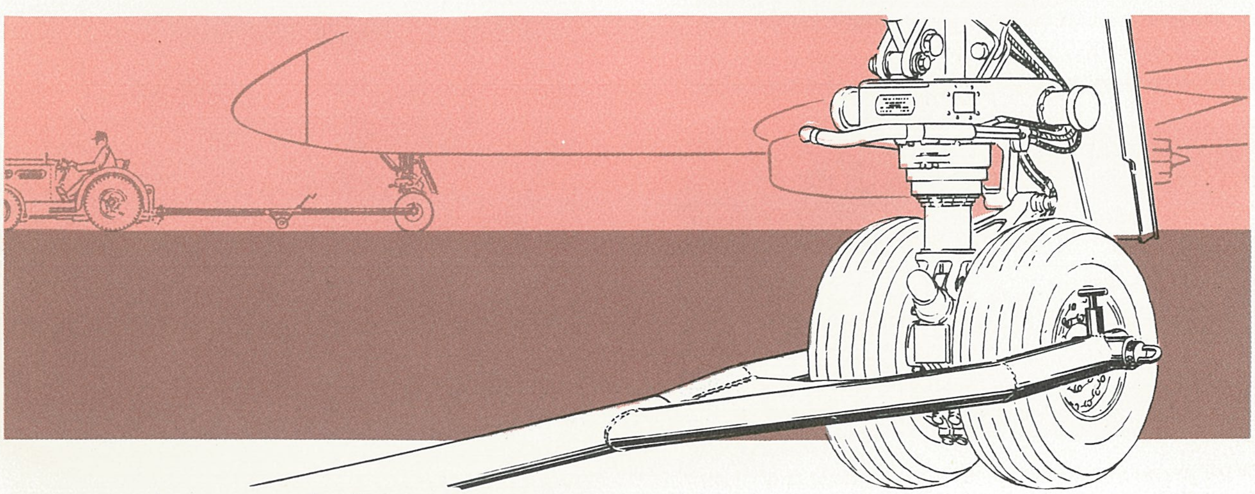
To assure adequate braking, an electric ground power cart, capable of delivering 115/200 volt, 3 phase, 400 cps should be connected to the airplane system, so that the auxiliary electric-driven hydraulic pumps can be operated to maintain hydraulic pressure for wheel braking. Wheel chocks should be available at all times during towing operations to block the airplane wheels in case of emergency.

If the airplane is to be towed at night, or when passengers are aboard, the electric power cart is needed to provide lights and for the purpose of operating the air conditioning system. A combination towing tug and electric power cart provides the ideal equipment for this purpose during all towing operations. The electric power source should be capable of supplying 25 KVA when the air conditioning system is to be operated; otherwise, 12 KVA is adequate for cockpit lighting, clearance lights, and operation of the auxiliary electric-driven hydraulic pumps.

During maintenance operations it may be necessary to tow the airplane with some of the components, equipment, or furnishings removed. When large components, such as engines, heavy equipment, or furnishings are removed from the airplane, the center of gravity is changed. The "880" airplane should not be towed when the center of gravity is aft of station 863, (station 901 on the "990") unless ballast is placed in the forward cargo compartment; otherwise, the airplane will be tail-heavy.

An example of this condition may be assumed to be an empty "880" airplane, weighing approximately 83,300 pounds, from which both inboard engines, the flight compartment seats and the electronic compartment gear have been removed. With this condition, 150 pounds of ballast, evenly distributed (20 pounds per square foot) must be loaded into the forward cargo compartment to compensate for the tail-heavy condition, prior to towing.

The number of persons required for a towing operation depends on the type of towing. The minimum required for nose landing gear towing is four persons; these include a towing tug operator, one man in the airplane flight compartment to operate the brakes, and one man at each wing tip to observe clearance. In the case of towing from the main landing gear, two towing tug operators are required, and one man is needed to guide the nose wheel tow bar; these are in addition to the man in the cockpit and the clearance observers. In most cases, towing speed should be held down to a fast walk of five or six miles per hour. Tug operators should avoid quick starts or stops. The airplane should be rolled before turning the nose gear so as to avoid scuffing the nose wheel tires.



Tow bar attachment at nose landing gear

OVERWING EMERGENCY EXITS

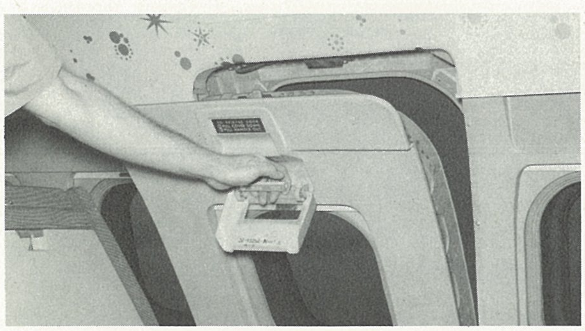
EXPEDITIOUS EVACUATION OF THE AIRPLANE, in event of an emergency, is facilitated by two emergency exits, one on each side of the fuselage over the wing. These exits are in addition to the fore and aft main entrance doors and the fore and aft service doors, which can also be used in event of an emergency.

The overwing exit door, approximately 20 inches wide by 36 inches high, is a plug-type door which opens inward. It is opened by activating a placarded recessed "T" handle from the inside, or a "Push-to-Release" plate from the outside, after which the door may be completely removed. When closed, the door is secured in place by an overcenter latching mechanism on its upper edge, and two hooks on its bottom edge. While in flight, the door is sealed by cabin pressure acting against a rubber seal around the periphery of the door.

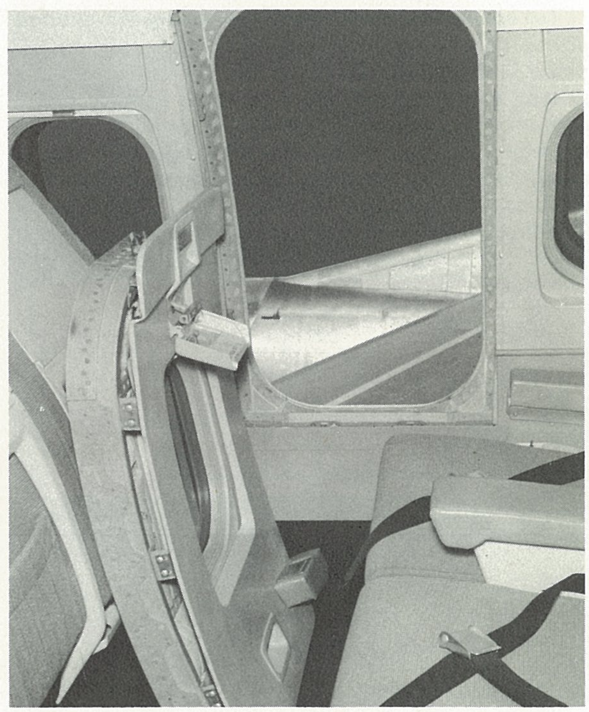
When the door is opened, either by pulling the interior "T" handle, or by pushing the exterior "Push-to-Release" plate, the latching mechanism at the top of the door unhooks, allowing the door to incline inward. By raising the door, the bottom hooks become disengaged from their sockets, and the door is freed. The door is replaced by inserting the bottom hooks into their sockets and pushing the door closed until the upper mechanism latches. A spring-loaded cover over the recessed "T" handle protects the unit from inadvertent unlatching. Children should be cautioned not to tamper with mechanism.

The armrest of the seat adjacent to the overwing exit is divided into two sections — one section is attached to the exit door, and the other section is fastened to the cabin wall. This installation prevents the armrest from interfering with removal of the door, and consequently interfering with evacuation of passengers. The section of armrest fastened to the cabin wall is long enough to accommodate normal fore and aft seat back adjustment.

Recessed "T" handle on inside of overwing exit door is protected by springloaded cover when not in use.



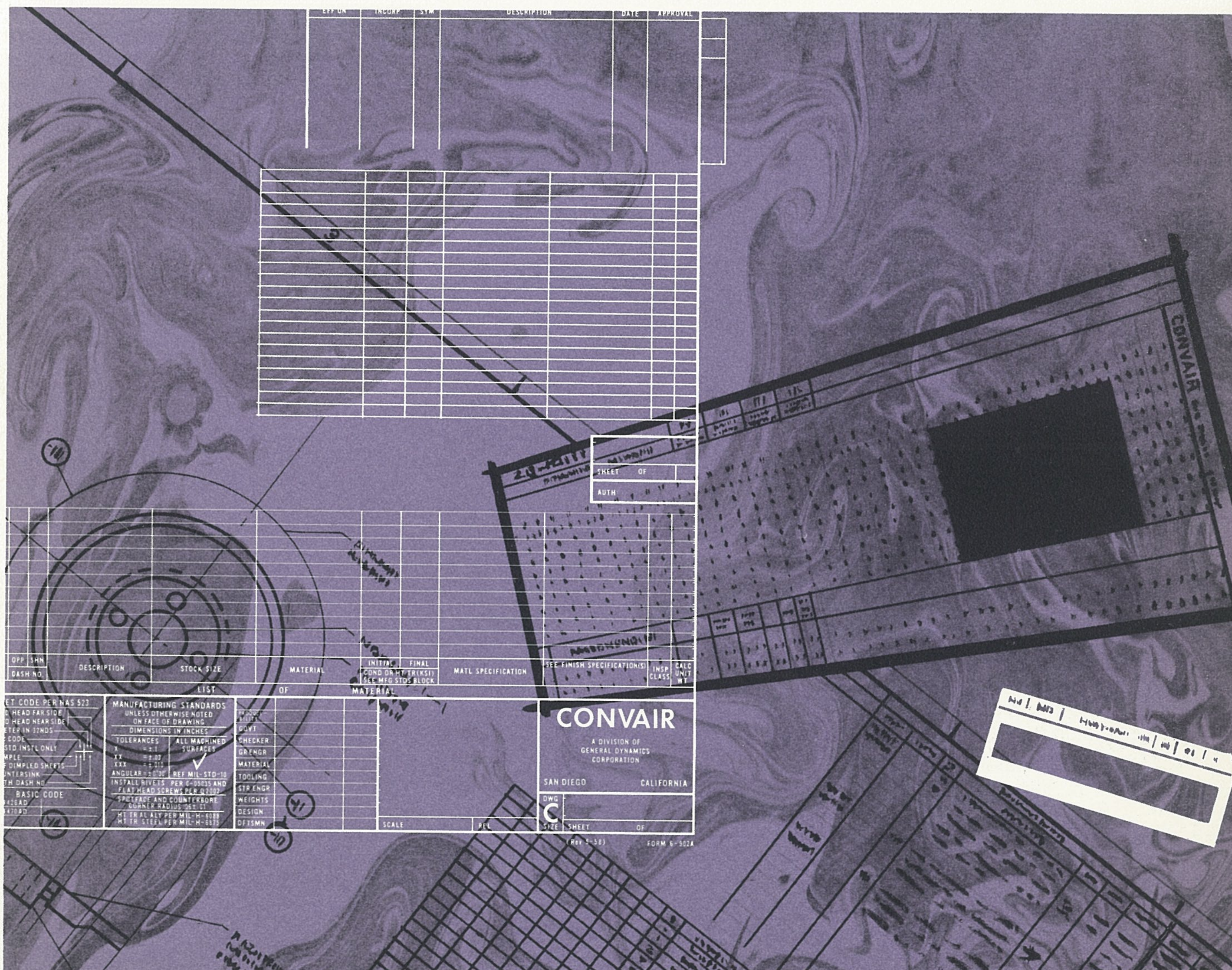
With protective cover opened, "T" handle is activated by pulling out. Action unlatches the top of exit door.



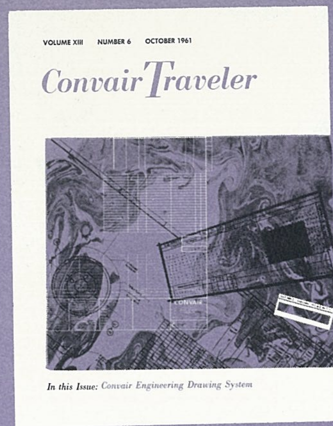
With aid of recessed handgrip at lower edge, door is lifted free of bottom retaining pins, and set aside.

VOLUME XIII NUMBER 6 OCTOBER 1961

Convair Traveler



In this Issue: *Convair Engineering Drawing System*



OUR COVER

Artist Harvey Adams' cover is a composite of various forms used in the Convair Engineering Drawing System, which utilizes Electronic Data Processing for presentation of information.

Convair Traveler

VOLUME XIII NUMBER 6 OCTOBER 1961

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IN THIS ISSUE

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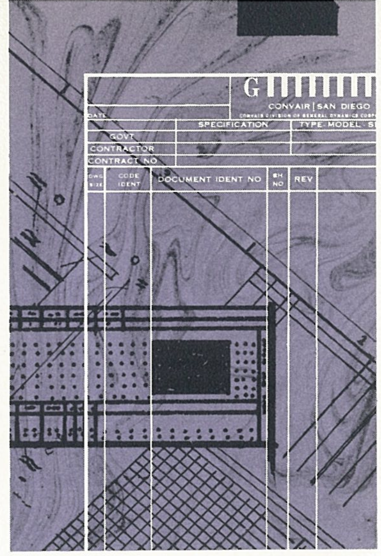
Convair

Engineering Drawing System



Electronic Data Processing is an integral part of the drawing system. Convair Drawing Room Manual (DRM) provides detailed information for this general outline.

THE CONVAIR ENGINEERING DRAWING SYSTEM contains three basic types of drawings. They include a one-sheet format, a two-sheet format, and a book form format. However, for most practical purposes and to enable a more thorough description, the three basic types will be broken down here into five categories.

1. *Electronic Data Processed Drawing.* This category consists of a two-sheet type of format, and it is discussed first because it represents the largest number of drawings in the system. Formerly depicted on the face of one or more drawing sheets was the pictorial and descriptive information needed to utilize that particular drawing. It is called an Electronic Data Processed drawing because certain data, which originally appeared on the face of the drawing, were removed and tabulated by means of electronic data processing. These data now appear on Sheet 2 and On, of the converted Electronic Data Processed Drawing. Drawings created after installation of the Electronic Data Processing System were made in two-sheet format.

2. *Tabulated Assembly Drawing.* This category of drawing contains a tabulated listing of all drawings which are required for a complete system, i.e., hydraulic, electrical, fuselage structure, etc.

3. *Book Form Drawing.* This category of drawing is one that is usually prepared to transmit specification data, or to present prose information in addition to a pictorial image, as opposed to a pictorial design layout. This category of drawing very often contains the kind of information that would be submitted to a vendor from which the vendor would design, prepare drawings, and manufacture a purchased part.

4. *Sheet 1 Status Record Drawing.* This category of drawing is the kind used for harness and wiring diagrams on Convair 880 airplanes. The Parts List is contained on the pictorial face of the drawing. Usage data are shown on Sheet 1, Aperture or Micro-Master Card.

5. *Harness Tabulated Drawing.* This category of drawing contains a tabulated listing of all wires, terminals, splices, etc., which are contained in the Convair 990 airplanes. Wiring diagrams and connection lists are also contained in this special type of a Book Form Drawing.

Convair engineering drawings are presented to customers of the Convair 880/990 airplanes in the form of Aperture Cards (35mm film mounted in an aperture of a 3¼ x 7⅜ inch tabulating card), Microfilmed Integrated Data Cards (film cut to 3¼ x 7⅜ inches), Micro-Master Cards (film cut to 4 x 6 inches), and reproducible transparencies (either 8½ x 11 or 11 x 17 inches).

Engineering drawings on film require considerably less storage area. The filmed drawing can be enlarged on a viewer for observation by large groups or by individuals. Disposable photoprints of the filmed drawing pictorial area and/or data can be quickly and economically reproduced by the customer at his facilities.

Each drawing is prepared for presentation to the customer as Drawing Sheet 1 (Aperture Card or Micro-Master Card) and as Drawing Sheet 2 and on (Microfilmed Integrated Data Card or Micro-Master Card or reproducible Transparency).

A typical conventional drawing is shown (Figure 1) for the purpose of illustrating the difference in the conventional drawing system and the Convair drawing system in its present form. It may be noted that the conventional drawing contains data in what may be described as seven general blocks or areas on the face of the drawing. For comparison and description each block or area of the face of the drawing has been assigned a number which relates directly to the identical number in the text following.

1 Title Block — drawing title, scale, size, number, sheet, and approvals; 2 Rivet Code & Manufacturing Standards Block — drawing preparation instructions, abbreviations, and specification references; 3 Application Block — airplane effectivity and applicability for part, sub-assembly, assembly, or installation; 4 List of Materials Block — quantities of bulk or raw materials required; 5 List of Parts — quantities required, parts numbers, and description of parts required for assembly into a sub-assembly, assembly, or installation; 6 Change Block — listing of all changes made to the drawing; 7 Pictorial Areà & Notes Area — the physical image layout of the part(s) described in the Title Block, and associated notes pertinent to the pictorial area of the drawing.

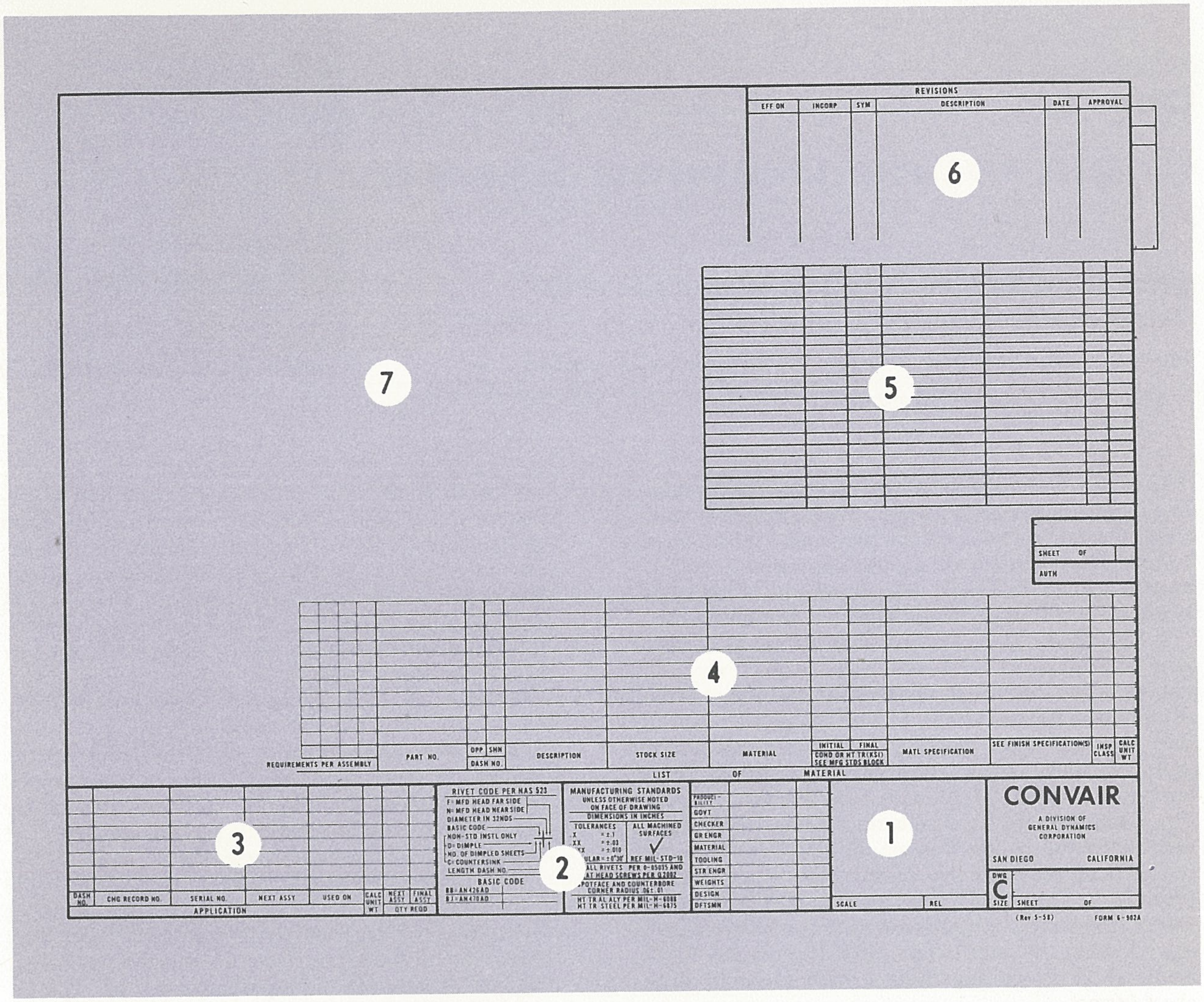


Figure 1. Typical engineering drawing. Many of these drawings, with block 5 deleted, are still in use.

A typical Convair mechanical engineering drawing, after conversion from the conventional drawing (figure 1), achieves compatibility with electronic data processing. The manner in which the conversion was accomplished may be followed by relating the numerals appearing in the various blocks and areas of the face of the drawing to those identical numerals appearing in the text following.

Data appearing in Blocks 1, 3, and 5 were prepared in tabular format, key punched on tabulating cards, stored on computer tapes, and identified as Table of Contents, Usage Data, and Parts List, respectively. Those data appearing in Blocks 2, 4, and Area 7 remained unchanged on the face of the drawing. Those data appearing in Block 6 were retained on the face of the drawing, and subsequent changes were prepared in the form of Engineering Change Notices.

The computer print-out form, containing the Table of Contents, Usage Data, Parts List, and unincorporated Engineering Change Notices, was photographed with a reduction of approximately 24 to 1 on 35mm film. The film was then mounted on an aperture in a standard size tabulating card called an Aperture Card (Figure 2), and depicts Drawing Sheet 1.

The entire face of the engineering drawing was photographed with a reduction of approximately 20 or 30 to 1, depending on the size of the drawing sheet, on a special foil bonded between two tri-acetate (film) sheets of the same dimensions as a standard size tabulating card called a Microfilmed Integrated Data Card and identified as Drawing Sheet 2 (Figure 3) or on.

Both Drawing Sheets 1 and 2, are presented to some customers with Sheets 1 and 2 on Micro-Master Cards.

The Aperture Card is the key to engineering information for each drawing in the Convair Engineering Drawing System. There is an Aperture Card for each drawing. The physical Aperture Card is always identified as Drawing Sheet 1 for each drawing. In addition to the information previously described as shown in the film aperture, it contains a heading area, and a key punch area. (See figure 2.)

The heading, which appears across the top of the card, is designed for identification purposes and to facilitate filing and locating the card. It contains the

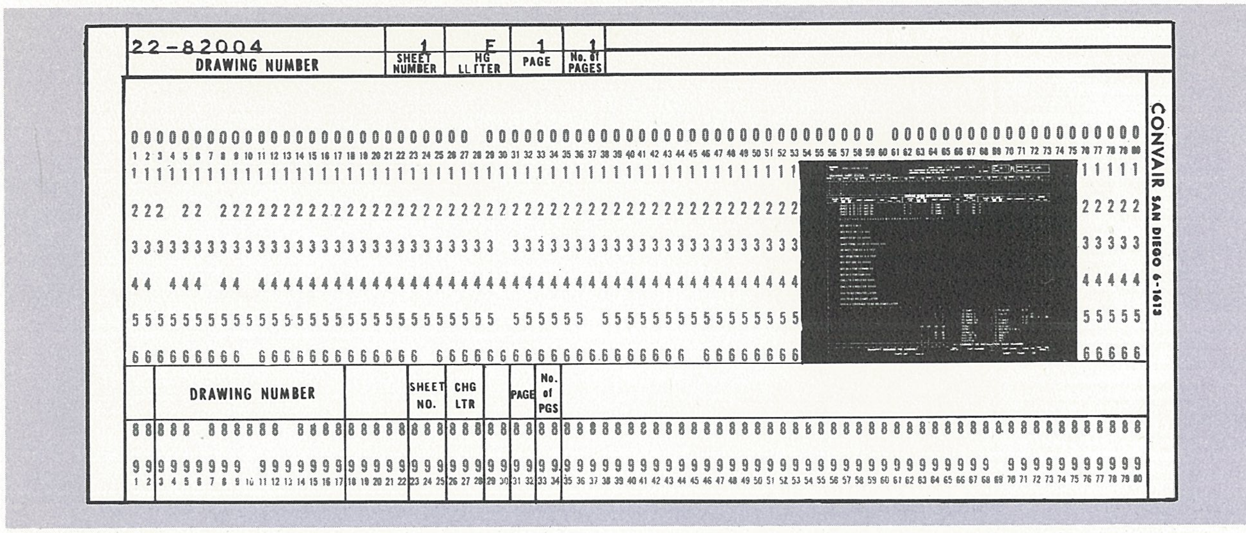


Figure 2. Typical aperture card contains key-punch area, and computer print-out form (figure 4).

Drawing Number, Sheet Number (which is always Sheet 1 for each drawing), Change Letter (which is the highest change letter for any and all sheets of that drawing including unincorporated Engineering Change Notices), Page Number (which is the page number of Drawing Sheet 1, also shown correspondingly in the upper right hand corner of the film area), and the Number of Pages (which is the number indicating the total number of pages, on the last page of Drawing Sheet 1 for each drawing).

The Key-Punch area is located in the left hand section of the Aperture Card, and contains the same information as that shown in the heading. The Aperture Card is key-punched to enable the customer to electronically sort the Aperture Cards in the event they have become misfiled, or if a large number of cards have been segregated in an order which is not compatible with the normal drawing number sequence of filing.

The key-punch area also serves another purpose with respect to the customer's activities. Periodically, according to contractual requirements, Convair supplies the customer with up-dating information in the form of new Aperture Cards to replace obsolete cards. The new up-dating Aperture Cards and the obsolete Aperture Cards in the customer file may be put on a collator which will automatically remove the obsolete cards and insert the up-dating cards and sequence the deck in one operation.

The Drawing Sheet 1 (Aperture Card) film area contains three major sections, previously described as Table of Contents, Usage Data, and Parts List. These

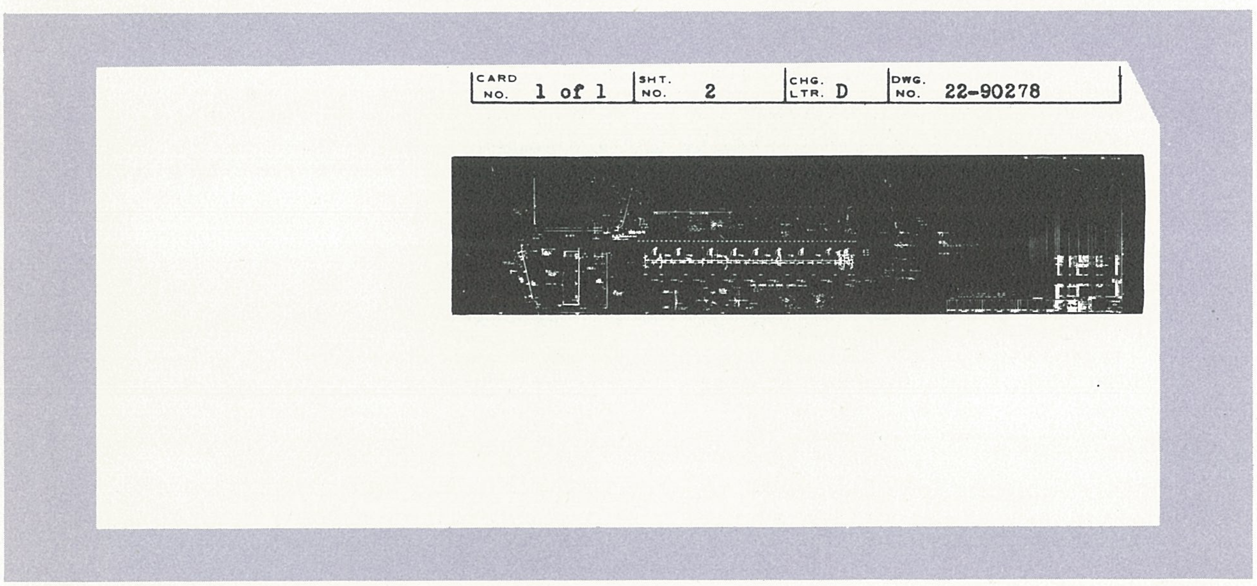


Figure 3. Microfilmed Integrated Data (MID) card contains engineering drawing pictorial information. This card is generally identified as Drawing Sheet 2 and On.

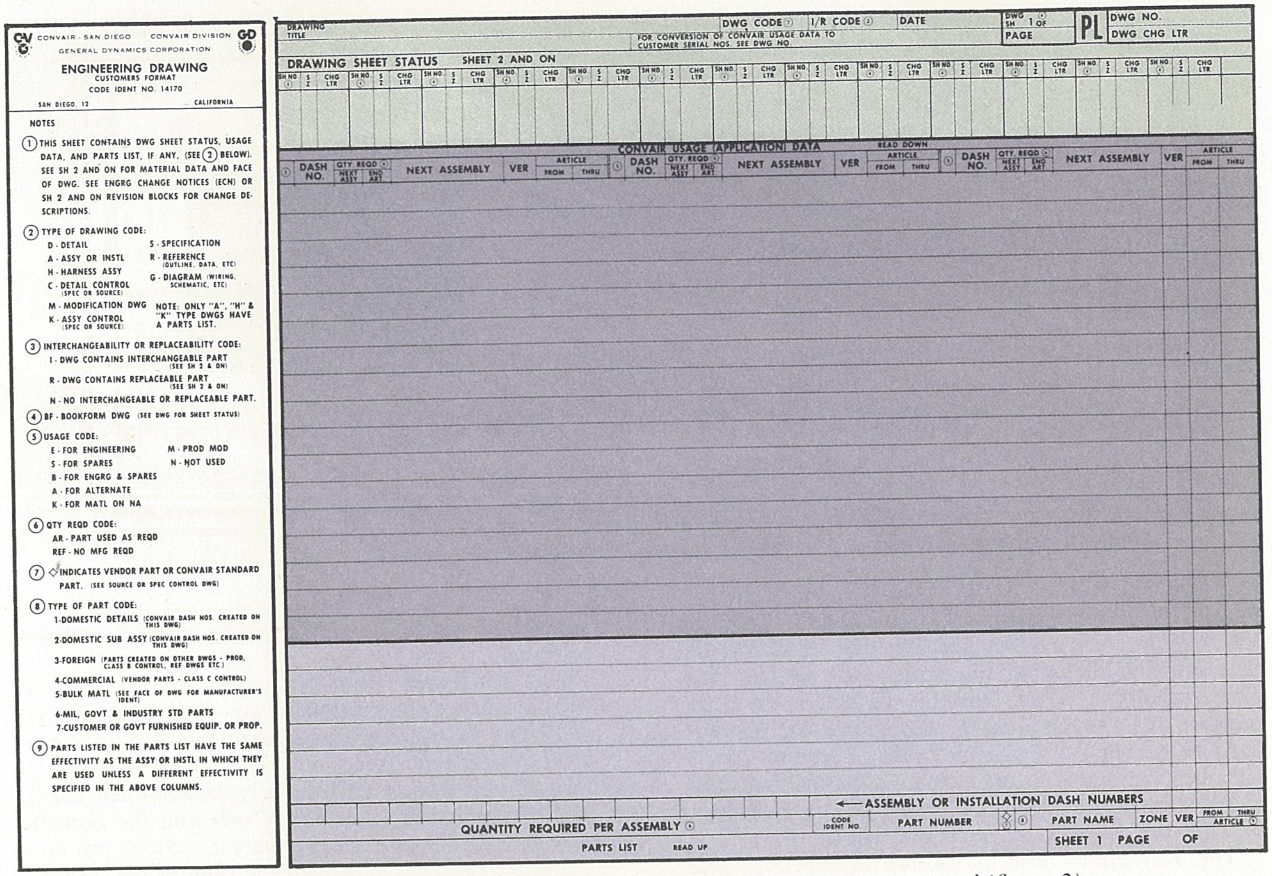


Figure 4. Computer print-out form appears in film area of aperture card (figure 2).

data are contained in columns, some of which are keyed by numerals to a code which appears along the left hand margin. The code consists of explanatory notes. The notes are, necessarily, brief and may be needed only occasionally after personnel are familiar with the data shown in the various columns. Meanwhile, some further amplification with respect to the explanatory notes and additional information with respect to the other columns may prove helpful to the user. (See key figure 4, and figures 5, 6, and 8.)

TABLE OF CONTENTS

The Table of Contents will be found in the upper section and in a smaller section in the lower right hand corner of the film area. Reading from left to right, line for line, across the top of the film will be found the Drawing Title; ② Dwg Code; ③ I/R Code; Date; ④ Dwg Sh 1 of _____; Dwg No; For Conversion of Convair Usage Data to Customer Serial Nos. See Dwg No; Page; Dwg Chg Ltr; Drawing Sheet Status Sheet 2 and On; (5) Sh No; SZ; and Chg Ltr.

Drawing Title — indicates the name by which the part, sub-assembly, assembly, or installation shown on Drawing Sheet 2 of this drawing is known.

② *Dwg Code* — indicates type of drawing with a letter, as follows:

A — Assembly or Installation drawing with all required information to assemble two or more parts to make a sub-assembly, assembly, or to install a sub-assembly, or assembly into an airplane.

C — Detail Control drawing with all information required by a vendor to manufacture a part(s) or to assemble parts to Convair specification requirements.

D — Detail drawing with all information needed to manufacture a single part.

G — Diagram or schematic of electrical wiring, etc.

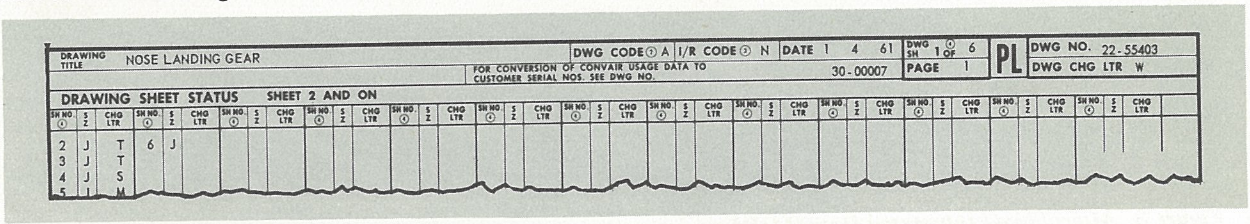


Figure 5. Typical Table of Contents area from computer print-out form (figure 4).

H — Harness Assembly drawing.

K — Assembly Control drawing with all information required by a vendor to assemble two or more parts to form an assembly, sub-assembly, or installation.

M — Modification Drawing.

R — Reference drawing with information in the form of an outline or reference material.

S — Specification drawing.

③ *I/R Code* — indicates interchangeability or replaceability code as follows:

I — Drawing contains an interchangeable part created on this drawing.

R — Drawing contains a replaceable part created on this drawing.

NOTE

If the part shown is both interchangeable and replaceable, it will be coded "I."

N — Drawing contains no interchangeable or replaceable part.

Date — indicates the date of the computer printout of the data shown on Drawing Sheet 1.

④ *Dwg Sh 1 of*_____ indicates the total number of sheets including Drawing Sheet 1 and Drawing Sheet 2 & on of this drawing.

Dwg No. — indicates the drawing number of the drawing to which the data shown pertains.

For Conversion of Convair Usage Data to Customer Serial Nos. See Dwg No. 30-00007 — indicates the Book Form drawing which relates the data in the Version/Article columns of Usage Data to the customer's identifying aircraft registration numbers.

Page — indicates the page number of Drawing Sheet 1.

Dwg Chg Ltr — indicates the highest change letter for this drawing, including outstanding Engineering Change Notices. Because one series of change letters is assigned per drawing, the change letter may affect only one or more sheets of the drawing, but not necessarily all sheets of the drawing.

Drawing Sheet Status — indicates the change status of Drawing Sheet 2 & on. This information is described in three columns headed Sh No., Sz, and Chg Ltr, as follows:

⑤ *Sh No.* — indicates the sheet number of pictorial drawing sheet with an entry for each such sheet. If the sheet number is "BF" the drawing is a Book Form drawing.

Sz — indicates the drawing sheet size of that particular sheet of the drawing.

Chg Ltr — indicates the highest change letter that has been incorporated on that particular sheet number of the drawing.

*Sheet 1 Page*_____*of*_____ — (shown in the lower right hand corner of Drawing Sheet 1) is the page number of this page of Drawing Sheet 1; only if this page is the last page will an entry be shown following the word "of."

USAGE DATA

The Usage Data will be found directly below the Table of Contents. It is divided into three sections, each of which contains the following column headings: ⑤ (Usage Code); Dash No; ⑥ Qty Reqd, Next Assy, End Art Next Assembly; Ver; Article, From, Thru.

⑤ *(Usage Code)* — indicates the usage or applicability of the part listed. Usage is coded by the use of a letter, as follows:

A — Alternate. For alternate use on the next higher level (next assembly) drawing.

B — Engineering & Spares.

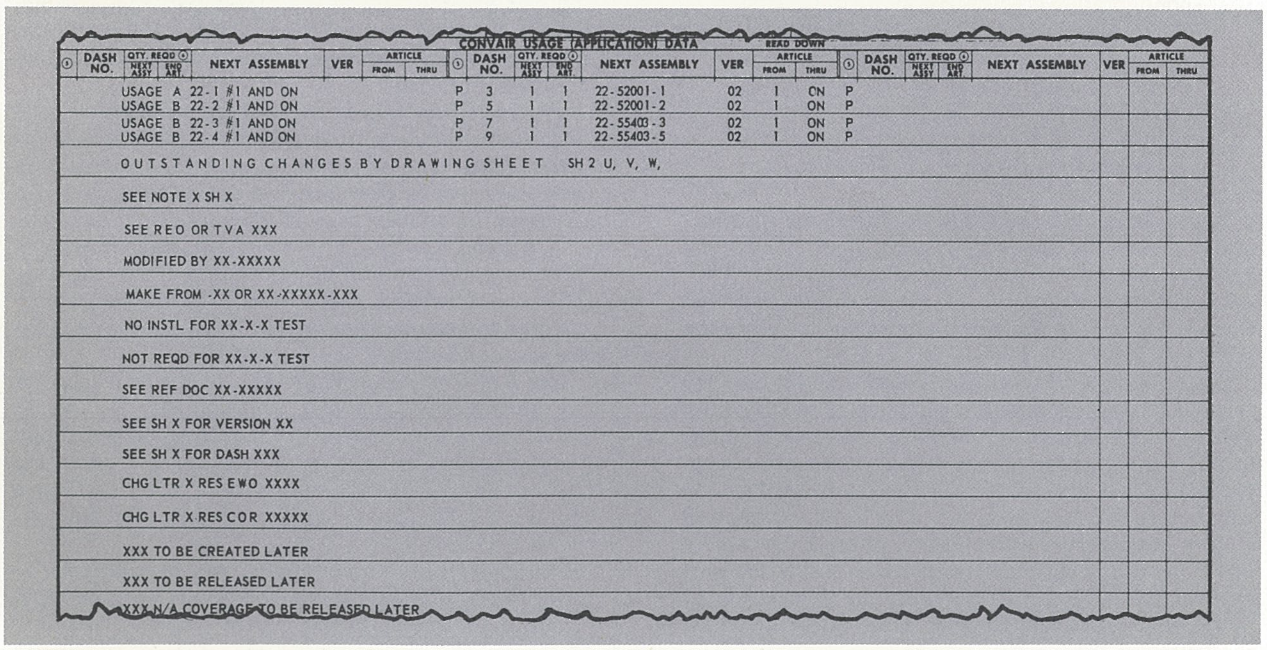

CONVAIR USAGE (APPLICATION) DATA
READ DOWN
⑤ DASH NO. | QTY. REQD ⑥ NEXT ASSY, END ART. | NEXT ASSEMBLY | VER | ARTICLE FROM, THRU
USAGE A 22-1 #1 AND ON P 3 1 1 22-52001-1 02 1 ON P
USAGE B 22-2 #1 AND ON P 5 1 1 22-52001-2 02 1 ON P
USAGE B 22-3 #1 AND ON P 7 1 1 22-55403-3 02 1 ON P
USAGE B 22-4 #1 AND ON P 9 1 1 22-55403-5 02 1 ON P
OUTSTANDING CHANGES BY DRAWING SHEET SH 2 U, V, W,
SEE NOTE X SH X
SEE REO OR TVA XXX
MODIFIED BY XX-XXXXX
MAKE FROM -XX OR XX-XXXXX-XXX
NO INSTL FOR XX-X-X TEST
NOT REQD FOR XX-X-X TEST
SEE REF DOC XX-XXXXX
SEE SH X FOR VERSION XX
SEE SH X FOR DASH XXX
CHG LTR X RES EWO XXXX
CHG LTR X RES COR XXXXX
XXX TO BE CREATED LATER
XXX TO BE RELEASED LATER
XXX N/A COVERAGE TO BE RELEASED LATER

Figure 6. Typical Usage Data area from computer print-out form (figure 4).

E — Engineering. For engineering design as opposed to a spare. (Older drawings will show "P" for engineering).

K — Material on N/A. For material to make a part on the next higher level (next assembly) drawing.

M — Production Modification. For production modification.

N — Not Used. For a part which is not required for one customer but is applicable as shown for for another customer.

S — Spares. For Spares only.

Dash No. — indicates the suffix which is to be added to the drawing number to make up the complete part number of that part.

⑥ *Qty Reqd* — indicates the quantity of that part required for the next assembly and for the end article. If the part is used as required, it will be coded AR; if no manufacture is required, it will be coded REF for reference data.

Next Assembly — indicates the part number of the next higher collection of components, such as a sub-assembly, an assembly, or installation into which the specific detail part, sub-assembly, or assembly is installed.

Ver — indicates the customer(s) by version number to which this part applies. (See Drawing 30-00007 for customer version definition.)

Article, From, Thru — indicates the Convair airplane number(s) to which this part applies.

NOTE

> Version is used to designate an airplane model. The term Article is used to distinguish different configurations of airplane models. The Convair 880 and 880-M airplanes are Models 22 and 22-M, respectively. The Convair 990 airplanes are Model 30. The Model 22's are built in Article (configuration) 1, 2, 3, 4, 21, and 22, or Model/Article 22-1, 22-2, 22-3, 22-4, 22-21, and 22-22. The Model 30's are built in Article (configuration) 5, 6, and 8, or Model/Article 30-5, 30-6, and 30-8. The designation 22-1 represents the first Model 22, Article 1, Airplane 1, of this series to be built.

Notes — indicates reference material for interpretation of information with respect to each Drawing Sheet 1, and will be found in the Usage Data. They are indented beginning in the Qty Reqd column and extend through the Article columns. Typical notes are as follows:

Usage A xx-x #x And On — Usage B #x And On — used to identify different methods of manufacture and usage of parts. It is sometimes more expeditious to put parts together one way than some other way. Occasionally a few parts have been put together one way before this is discovered. When this occurs, and it does not affect interchangeability or replaceability of the part, it is unnecessary to create a different part number to differentiate between the two types of fabrication; however, Convair must know in which configuration the airplane was delivered. These notes are used to distinguish which airplanes were assembled with the part put together as "A" and which airplanes contained the part put together as "B."

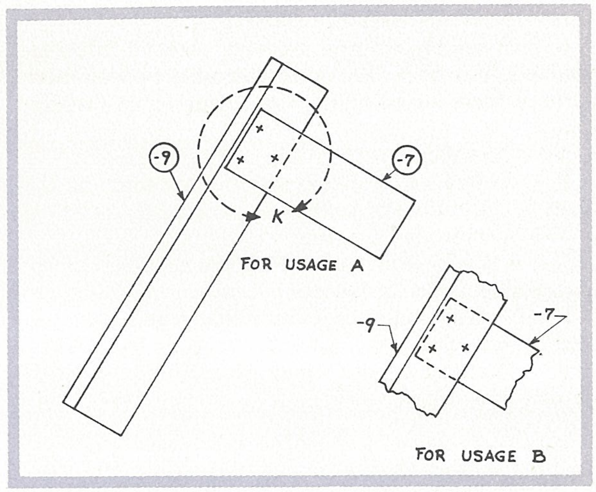


Figure 7. Means of identifying different methods of manufacture and/or usage of parts.

See Note x Sh x — used to identify notes appearing on Drawing Sheet 2 which contain such information as vendor names, etc.

See REO or TVA xxx — used to identify drawings modified by REO (Rework or Retrofit Engineering Order) or TVA (Temporary Variation Authority). These notes have no significance in the present Convair Engineering Drawing System where RECN's (Rework Engineering Change Notices) are used for this purpose.

Modified by xx-xxxxx — used to identify drawings modified by a Modification Drawing.

Make From -xx or xx-xxxxx-xxx — used to identify a part which contains a part created on another drawing, but which has been taken from the other drawing, altered in some manner and given a different part number for use on this particular drawing. It is called a Make From part.

No Instl For xx-x-x Test — used to identify parts which must not be installed during testing of the airplane. This type of note is used to preclude the installation of a part because space here is being reserved for another part on the completed airplane.

Not Reqd For xx-x-x Test — used to identify parts which are not required during testing of the airplane. The part could be carpet which if installed should be covered to keep it clean or left out of the airplane for the test and installed at a later date.

See Ref Doc xx-xxxxx — used to identify released documents on this drawing. This note will also appear on Drawing Sheet 2, and contains a reference which the designer considered to be necessary to convey the information on the drawing. These notes contain a list of all reference documents necessary to this particular drawing.

See Sh x For Version xx — used on diagrams to identify the airplane effectivity with the sheet number. There are some drawings where Convair creates a particular sheet for a particular customer. A basic sheet is prepared with the information on it, and then

a supplemental sheet is prepared for each customer. This is usually done with respect to drawings which have a large number of sheets, to enable the customer to look in the Usage Data to tell which specific drawing sheet he desires and eliminate the need for thumbing through many sheets of a drawing.

See Sh x For Dash xxx—used on diagrams to identify the dash number with the sheet number, for ease of use of a multiple sheet drawing.

Chg Ltr x Res EWO xxxx—used to identify change letter reservations for future changes and the authority for the change.

Chg Ltr x Res COR xxxxx—Same as above.

xxx To Be Created Later—used to identify parts not yet created but whose next assembly is released.

xxx To Be Released Later—used to identify unreleased assemblies whose components are releasd.

xxx N/A Coverage To Be Released Later—used to identify parts whose next assembly is not yet released.

As stated previously, Usage Data is tabulated in three sections, each of which contains identical headings. It is read from the top to bottom of the first section, then from the top to bottom of the second section, and from the top to bottom of the third section. The order in which the dash numbers appear is flush left. The procedure followed is to put the most left hand column of digits in order numerically without regard to the other numbers which form that dash number; then put the second column of digits in order in the same manner, and proceed to the third column of digits. This system is known as "Flush Left." It means that the numbers of dash number do not necessarily fall into numerical sequence, except with respect to the individual columns of digits. A sequential arrangement would be 1, 7, 9, 10, 11, 21, 200. A "Flush Left" arrangement would be, for the same dash numbers: 1, 10, 11, 200, 21, 7, 9. In other words, 200 will not be found following 199, it will be found by finding its terminal left hand digit 2.

At the end of the Usage Data there will frequently be found a line listing *Outstanding Changes By Drawing Sheet.* This will be followed by a line for each sheet and the change letters of the outstanding Engineering Change Notices pertaining to that sheet. "Outstanding" means that the changes are outstanding only against Drawing Sheet 2 or On, as applicable to a specific customer's airplanes. The Parts List and Usage Data on Sheet 1 are always up-to-date with the latest changes listed.

Usage Data may continue as far down the page or for as many pages of Drawing Sheet 1 as are required to contain all Usage Data for each particular drawing.

PARTS LIST

The Parts List of Drawing Sheet 1 will be found following the Usage Data. The Parts List is separated from the Usage Data by a line of asterisks and the words Parts List. Data in the Parts List is read, line for line, left to right across the page from top to bottom. The column headings for Parts List data are shown at the bottom of the page. The column headings include: ⑥ Quantity Required Per Assembly; Code Ident No; Part Number; ⑦ (Symbol); ⑧ (Part Code); Part Name; Zone; Ver; ⑨ Article, From, Thru; and Assembly Or Installation Dash Numbers.

⑥ *Quantity Required Per Assembly*—indicates the quantities required of the parts shown in the Part Number column on the corresponding line.

Code Ident No.—indicates the Federal Number assigned to each design activity or supplier of material or equipment to the government. Code Ident Nos are listed in Federal Catalog H-6 and show the name and address of the design activity or supplier for each assigned number. This column is not used at the present time because the use of Code Ident Nos is under consideration by the ATA for commercial use.

Part Number—indicates the part numbers of all parts required for the subassemblies, assemblies, or installations which are created on this drawing.

⑦ *(Symbol)*—indicates that the part shown on this line is a Convair or vendor standard part, the design of which is controlled by its own drawing.

⑧ *(Part Code)*—indicates type of part code with arabic numerals, as follows:

1—Domestic Detail. Convair detail dash numbers created on this drawing.

2—Domestic Subassembly. Convair assembly dash numbers created on this drawing.

3—Foreign. Parts created on other drawings, such as production, specification control drawings, reference drawings, and assembled into this drawing.

4—Commercial. Vendor parts which are controlled by Convair standard drawings.

5—Bulk Material. See Drawing Sheet 2 for manufacturer's identification, name, and address.

-9	-7	-5	-3	CODE IDENT NO.	PART NUMBER	⑦	⑧	PART NAME	ZONE	VER	FROM	THRU
			1		22-55403-7		2	PLACARD	B 25			
		2	2		22-02476-5	◇	3	VALVE		02	1	1
		2	2		22-02476-5	◇	3		A 27	02	6	ON
			1		93-84500-018	◇	4	FLANGE	A 27			
			1		94-16034-001	◇	4	GASKET	A 27			
AR	AR	AR	AR		253363	◇	5	SEALANT				
*	*	*	*		253363	◇	5	SEE NOTE 3 SH 2				
		20	20		AN960C8L		6	WASHER				
2		10	10		NAS1103-16		6	BOLT				
	2	10	10		NAS1103-12		6	BOLT				
2	2				NAS679A6		6	NUT				

← ASSEMBLY OR INSTALLATION DASH NUMBERS

QUANTITY REQUIRED PER ASSEMBLY ⑥ — ARTICLE ⑨

PARTS LIST READ UP — SHEET 1 PAGE 1 OF 1

Figure 8. Typical Parts List from computer print-out form (figure 4).

6 — Military, Government, and Industry Standard Parts. Parts conforming to specifications or drawings which are standard usage throughout military, government, and industry.

7 — Customer or Government Furnished Equipment or Property. Equipment or property supplied to Convair for installation in a customer's airplane.

Part Name — the noun name by which the part appearing on this line is identified in all Convair documents.

Zone — All large Convair drawings which have pictorial areas where the location of a part might otherwise be difficult to find are zoned. Zoning means that the margins of the drawing sheet are numbered horizontally and lettered vertically. If a part is zoned B 4, in the zone column, it will be found in the pictorial area of Drawing Sheet 2 by finding "B" in the vertical margin and "4" in the horizontal margin.

9 *Version, Article, From, Thru* — Information will appear in these columns only when the physical use of a part is different than the assembly in which it is used. Occasionally a part may be fabricated in a different manner for one or more airplanes than it is for other airplanes for the same customer. If the installation of the part does not affect the serviceability of the assembly, nor its interchangeability or replaceability, the part number of the assembly will not be changed. This is Convair's method of controlling the effectivity of part usage in every airplane at the time of manufacture and delivery to the customer.

Assembly Or Installation Dash Numbers — Space is provided here for listing sixteen subassembly, assembly, or installation dash numbers. The first part created on a drawing may be called the basic part, and does not have a dash number assigned to it. When the basic part is shown in the Parts List, the letters "BAS" will appear in this column.

Notes — When a note is required to supply additional information with respect to a part listed, an asterisk will appear in the Assembly column for that part. The appropriate note will be found beginning in the Part Name column and extending through the Article columns. Typical notes follows:

See Note x Sh x. — used to identify notes on Drawing Sheet 2 or On which contains such information as vendor's name, etc.

Alt For -xx or xx-xxxxx-xxx — used to identify alternate parts.

Make From -xx or xx-xxxxx-xxx — used to identify parts which have been created and released on other drawings, but which are taken from the other drawing, altered in some manner and given a different part number for use on this drawing.

No Instl For xx-x-x Test — used to identify parts which must not be installed for test because this space is reserved for another part which is to be installed for the final airplane configuration.

Not Reqd For xx-x-x Test — used to identify parts which are not essential to the testing of the airplane, such as carpeting, which would have to be covered during testing to preserve it for delivery of the airplane.

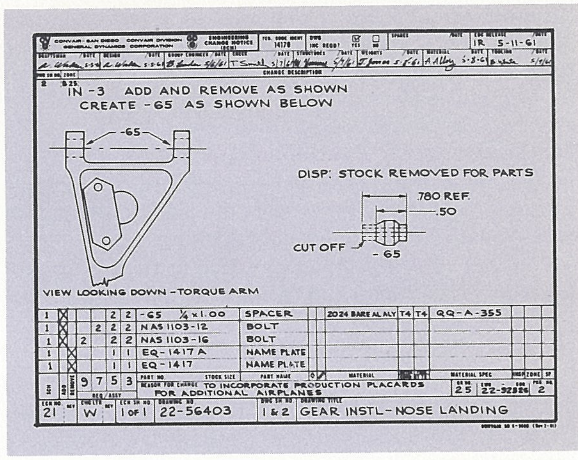


Figure 9. Typical Engineering Change Notice (ECN).

The Engineering Change Notice is a document used to describe and, if necessary, illustrate a change to an engineering drawing. It will be listed on Drawing Sheet 1, if the information has not been incorporated on the face of drawing. An Engineering Change Notice contains five blocks or areas of information, which may be described as 1 General Heading; 2 Change Description; 3 Pictorial Area; 4 List of Materials; and 5 Document Data Block. While each block or area contains considerabble information, the user need only be concerned with some of these data.

1 *General Heading.*

2 *Change Description Block* — contains the number of the Drawing Sheet; Zone of drawing where change is to be made; and Description of the Change.

3 *Pictorial Area* — illustrates pictorial area of change as change is to be made.

4 *List of Material Block* — describes material required to make part or bulk material needed for change and the effectivity.

5 *Document Data Block* — indicates number of Engineering Change Notice; Change Letter; Sheet Number of Engineering Change Notice; Drawing Title; Drawing Number; and Drawing Sheet(s) affected by Change.

The Microfilmed Integrated Data Card is the key to all pictorial information in the Convair Engineering Drawing System. The physical Microfilmed Integrated Data Card is always identified as Drawing Sheet 2 or On, for each drawing except Sheet 1 Status Record Drawings which have two Sheet 1's. The card contains both a film area and a heading area.

The heading, which appears across the top of the card, is designed for identification purposes and to facilitate filing and locating the card. It contains the Sht No; Chg Ltr; and Dwg No. The film area contains the List of Materials; Parts List for Sheet 1 Status Record Drawings; Change Block; General Notes; and Pictorial image Area of the drawing.

Sht No. — indicates the drawing sheet number of the sheet of the drawing that is shown on this card.

Chg Ltr — indicates the highest change letter of the change that has been incorporated on the sheet of the drawing shown on this card.

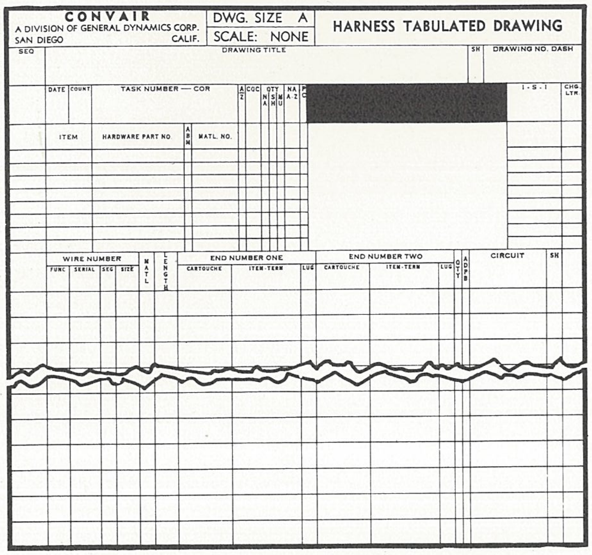


Figure 10. Electrical harness connection lists are furnished in reproducible transparencies.

Dwg No.—indicates the drawing number of the drawing shown on this card.

List of Material—contains each detail part created on this drawing; material from which the part was made, including stock size, type of material, heat treat, material specification and finish, and inspection class; zone of the drawing where the detail part is shown.

Parts List — contains parts for Sheet 1 Status Record Drawings that are required for the subassemblies, assemblies, or installations which have been created on this drawing; and the quantity of each part required for each subassembly, assembly, or installation.

Change Block — contains a record of each change that has been incorporated on this sheet of the drawing.

General Notes—Contain vendor's name and address for bulk material called out in the Parts List; installation notes; and reference documents.

Pictorial Area—contains the pictorial "image" of the drawing.

Electrical harness and connection lists are presented to the customer on either 8½ x 11 or 11 x 17 inch reproducible transparencies (Figure 10) for the Convair 990. These are a special type of Book Form Drawing.

Three types of lists are provided with engineering drawing data. Each list is prepared in the same format, but is titled Drawing Index List, Shipping List, or Shortage List, depending on the type of list. Each list contains a heading which includes the Convair aircraft model number (22, 22-M, or 30); the customer's name; the sheet number of each sheet of the list; and, on the last sheet, the total number of the total number of sheets, the date of the list, which is the compilation date. The contents of the list includes Size; Document Ident; Sheet No; Rev; Document Nomenclature.

Size—indicates the size of Drawing Sheet 1 or On.

Document Ident—includes drawing number.

Sheet No.—the sheet number of the drawing.

Rev—is the highest revision change letter incorporated on the drawing sheet.

Document Nomenclature—indicates the title of the drawing. An "X" following the title shows that the complete title is not listed.

The Drawing Index List shows all sheets of all drawings which are to be supplied to a customer, in accordance with the purchase agreement. This is the master list of all engineering drawing data to be supplied as Drawing Sheet 1 on Aperture Cards or on Micro-Master Cards; Drawing Sheet 2 on Microfilmed Integrated Data Cards or on Micro-Master Cards; or on Reproducible Transparencies. The list is supplied periodically, and always with the first and last submittals of engineering drawing data.

The Shipping List is a tabulation of drawings supplied in a particular shipment. The Shortage List indicates the sheets of the drawings to which the customer is entitled in a particular shipment, but which are not included in that shipment because the drawing may be undergoing changes and cannot be completed in time for shipment. These shortages are listed as part of the requirements to be included in a future shipment. If necessary, a Shortage List accompanies each shipment.

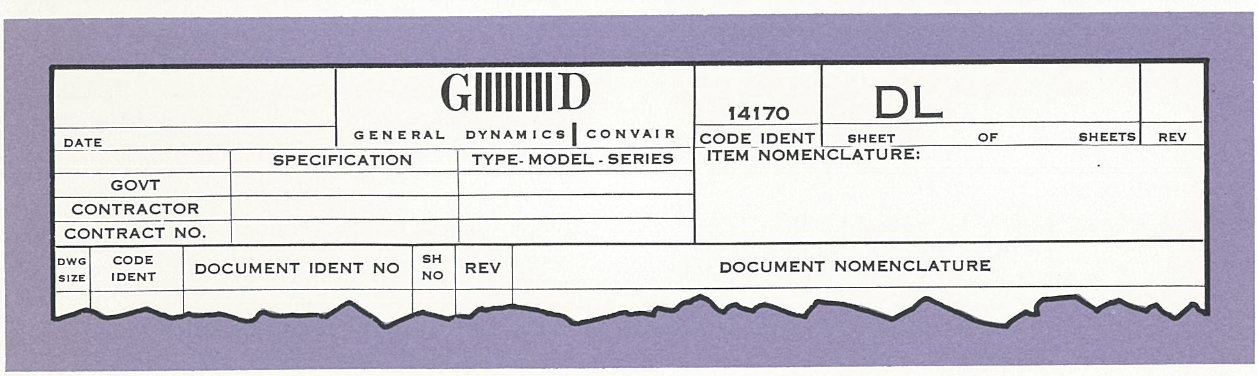


Figure 11. This form is used for Drawing Index, Shipping, and Shortage lists. Its usage is typed in space provided in upper RH corner.

Lavatory Drain Caps

Convair 880

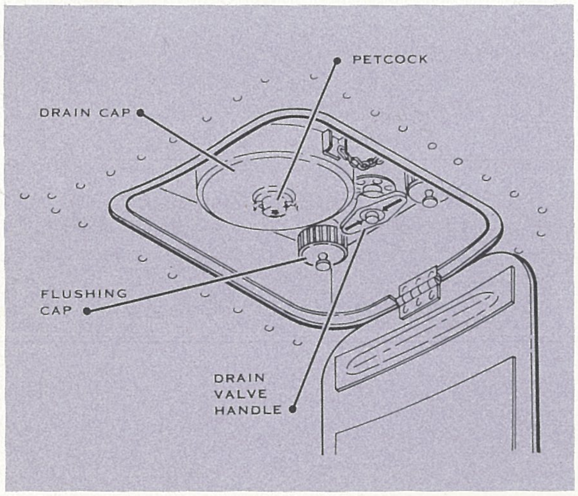
PROPER SEATING OF ALL CAPS is necessary after flushing and servicing the lavatory waste tanks. An improperly seated and/or sealed cap can cause air to leak overboard through the drain opening. Damage to plumbing and equipment can result.

The three lavatories in the Convair 880 jet airliner are serviced at two locations: the forward lavatory at station 347, left-hand side, just below the main entrance door; and the two aft lavatories at one panel at station 1331, bottom centerline of the fuselage. Draining and flushing facilities and instructions are provided at each panel.

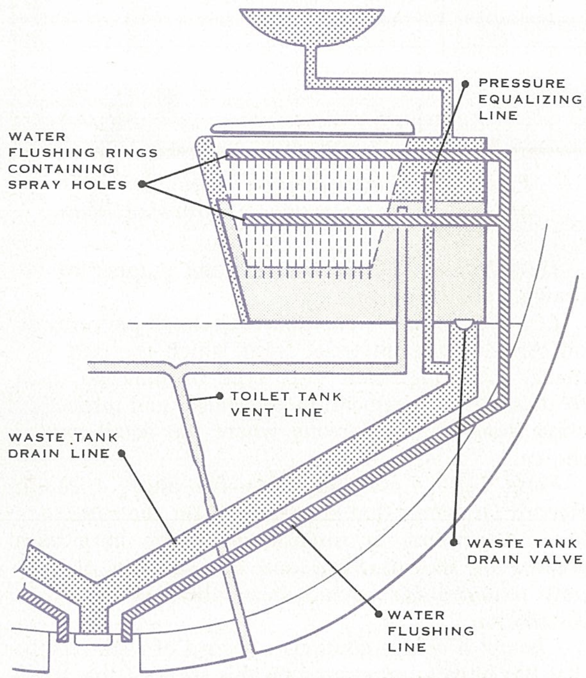
Each drain tube is sealed off at its upper end (at bottom of waste tank) by the waste tank drain valve, and at the servicing connection by the cap. A small vent line (or pressure equalizer line) is connected to the drain tube just below the tank drain valve, so that cabin air pressure around the tube and within the tube will be equal at all times. There are no vent lines connected to the flushing lines because the spray holes serve as the pressure equalizing vents.

An improperly sealed cap will permit air to leave the drain tube and, since the vent tube cannot provide sufficient air to equalize the differential pressure, the drain tube could collapse.

A new type cap seal (Airaterra, P/N 2651-178) gives a definite indication of bottoming of the cap when the cap is rotated ¼ turn to lock. The seal, which is similar in action to an O'ring, eliminates wiping against the nipple when the cap is installed and rotated. When the cap reaches the positive detent locking position, a green indicator in the drain cap appears.



The petcock in the drain cap should be opened, before flushing the waste tank, to drain any liquids that may have seeped into the drain tube. It is important that this petcock be closed after draining so that, upon subsequent cabin pressurization, an equalization of cabin pressure will take place within the drain line tube.

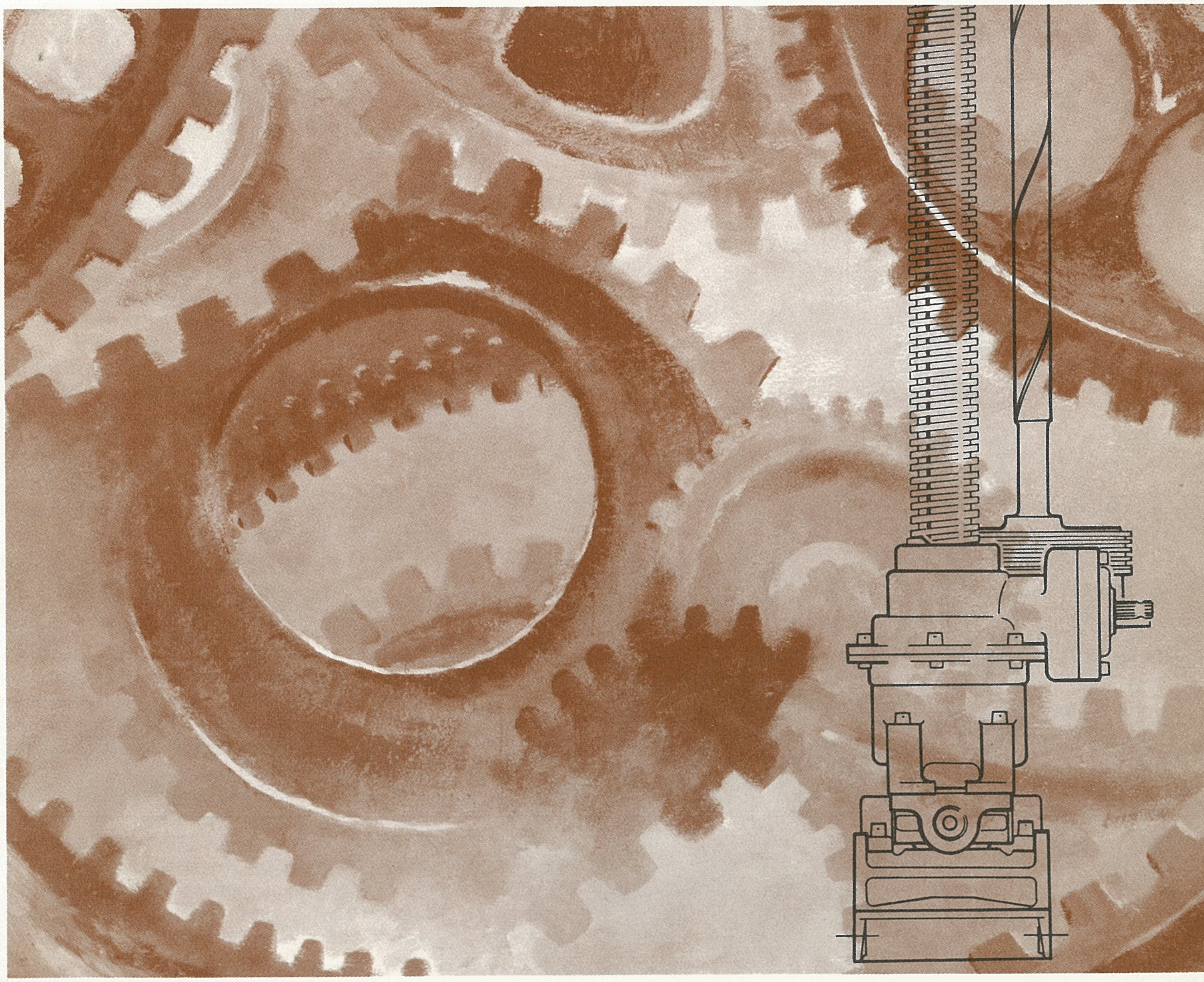


Each of the sealing caps on the flush and drain lines should be inspected at each servicing to insure that:

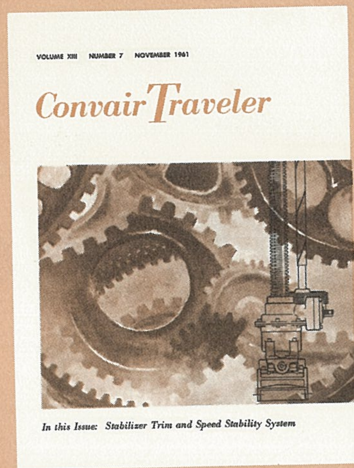
1. All caps are in good condition, and clean.
2. Cap seals are in good condition and properly seated in the caps.
3. Caps are installed and locked without imposing damage to the seals.
4. The large drain cap not only shows green on its indicator, but also engages the locking detents (snapped into the fully locked position), and does not readily start to turn off under light hand force.
5. The petcock in drain cap is closed.

VOLUME XIII NUMBER 7 NOVEMBER 1961

Convair Traveler



In this Issue: Stabilizer Trim and Speed Stability System



OUR COVER

The phantom array of gear teeth and screw jacks, shown on this month's cover, symbolizes the efficient mechanism used in the trim and stability system of the Convair 880. The artist is Bob Kemp.

Convair Traveler

VOLUME XIII NUMBER 7 NOVEMBER 1961

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IN THIS ISSUE

A digest of operation and service published monthly by the Service Publications Sections of Convair Customer Service Department in the interest of Convair operators. Communications should be addressed to the Manager of Customer Service Department, Convair, San Diego 12, California. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without specific approval of their cognizant organization.

GENERAL DYNAMICS | CONVAIR

STABILIZER TRIM AND SPEED STABILITY SYSTEM

LONGITUDINAL TRIM IN THE CONVAIR 880 is obtained by changing the angle of attack of the entire horizontal stabilizer. The mechanism that moves the stabilizer resembles that in some other jet aircraft of comparable size and speed in that it utilizes a screwjack; but closer examination of the mechanism will show more differences than resemblances.

The distinctive features of the "880" stabilizer mechanism are these: 1) Normal operation is hydraulically powered. Trim control wheels, "beep" trim switch, and the autopilot all operate the hydraulic power unit. 2) Emergency trim is electrically powered; if electric power is not available, trimming manually from the cockpit is possible. 3) Automatic nose-up trim is provided normally for all airspeeds above 200 kts IAS.

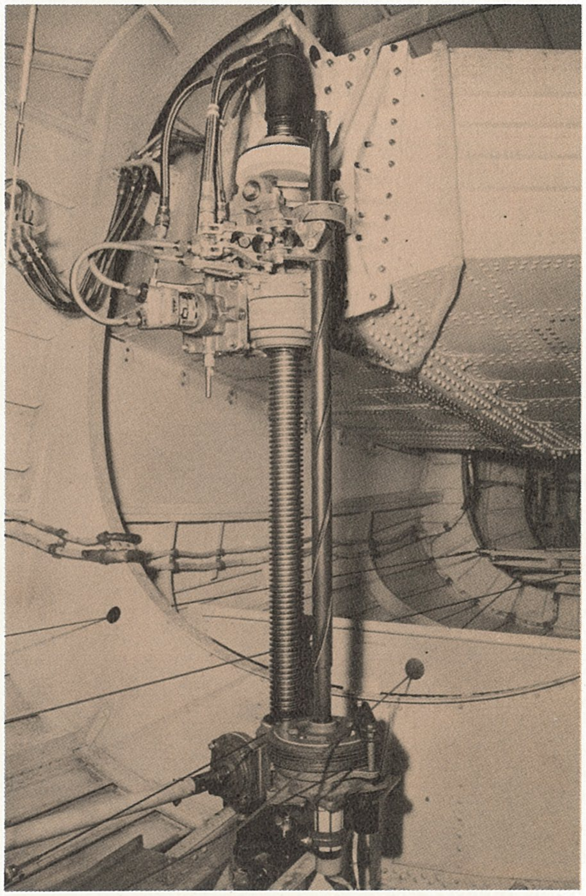
NORMAL OPERATION

The stabilizer actuator is composed of a screwjack with an Acme thread; a second shaft, with double helical grooves, that serves for control valve input and also as a followup; an upper gimbal assembly, attached to the stabilizer structure, with the control valve and a hydraulic motor driving a traveling nut; and a lower gimbal assembly with a cable drum for input from the flight deck, a servo motor for speed stability system input, and an emergency mechanically-operated gear drive.

In normal operation, the cable drum is rotated by cables from the flight compartment. Through an internal planetary gear system, the drum turns the helical control shaft. In the control valve mechanism on the upper gimbal, a ball-nut turns with the helical control shaft and operates the servo valve through a lever linkage. The valve ports fluid to operate the hydraulic motor. A worm on the hydraulic motor shaft drives the traveling nut, which has the worm gear on its outside face and is internally threaded for the screwjack. As the traveling nut moves the upper gimbal up and down the screwjack, the servo valve mechanism moves on the helical control shaft; its ball-nut follows the helical grooves, thus functioning as a follow-up to close the valve when actuator travel matches the input from the cable drum rotation.

Full travel of the upper gimbal is just under two feet. This results in a range of stabilizer movement from streamline to 14° stabilizer leading-edge-down (airplane-nose-up trim).

At the flight compartment end of the cable system, the actuating cable drum, beneath the center pedestal, is driven by one of three means: 1) *Manually, by a pair of trim wheels,* one on each side of the center pedestal, geared to the cable drum. 2) *Electrically, by a "beep" trim system.* A 28-volt DC motor is connected to the cable drum by a chain-and-sprocket drive. The motor is controlled by thumb switches on each pilot's control yoke. 3) *Electrically, by the autopilot,* through a second motor operating through the same chain drive.



Screwjack is attached to fuselage structure at bottom, and to nose of stabilizer torque box at top.

Although trimming by manually turning the trim wheels on the pedestal is often referred to as the "normal" mode of operation, the pilots usually find the control yoke button much handier. Almost 11 turns of the trim wheel are required to obtain the full amount of stabilizer travel. This ratio makes the wheel useful for fine trim; but pilots soon learn to handle beep trim with fair precision. The beep trim motor has practically no overrun, or "coasting," and it moves the stabilizer just as fast as the system will allow. Should both pilots attempt beep trim at once, the pilot's button overrides the copilot's. Beep trim is locked out when the autopilot — either Bendix or Sperry — is engaged.

Rate of stabilizer movement, up to an indicated airspeed of 250 kts, is .4° per second. Above this speed, trim rate is limited to .2° per second. This reduction is obtained by restricting the flow to the trim actuator servo valve. The selector valve that restricts the flow is normally closed and is held open at low speed by electrical power. A "Q" (dynamic air pressure) sensor located downstream of the copilot's pitot-static shutoff valve deenergizes the hydraulic selector valve at approximately 250 kts IAS, closing the valve and forcing hydraulic flow through a fixed-orifice restrictor.

In aircraft with the Bendix autopilot, flow is further restricted when the autopilot is engaged. Autopilot trim rate is only .1° per second. This restricted rate is obtained by forcing flow through a smaller restrictor; a second restrictor and selector valve are required in this hydraulic line to program flow according to "Q" pressure during manual flight. When the autopilot is disengaged, flow rate returns to that programmed by airspeed.

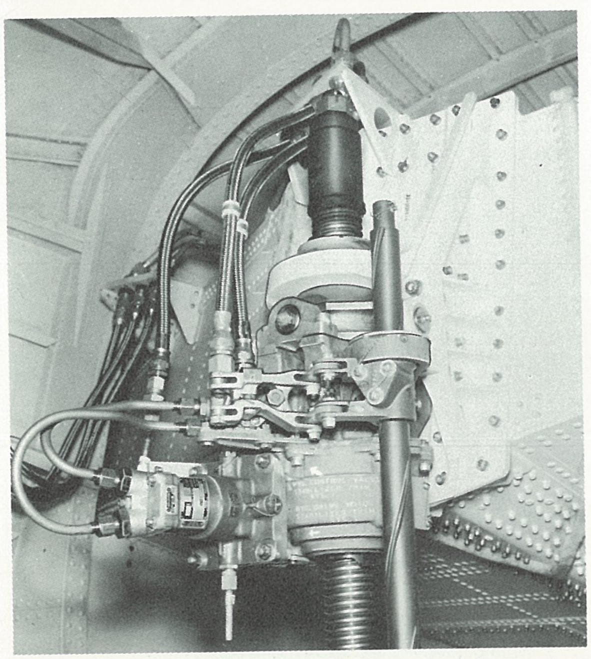
When the main landing gear is extended for speed-braking at speeds in excess of 250 kts, the available stabilizer rate will automatically increase to .4° per second while the gear is in transit, reverting to the rate demanded by airspeed when the gear is down and locked and the doors closed.

EMERGENCY TRIM

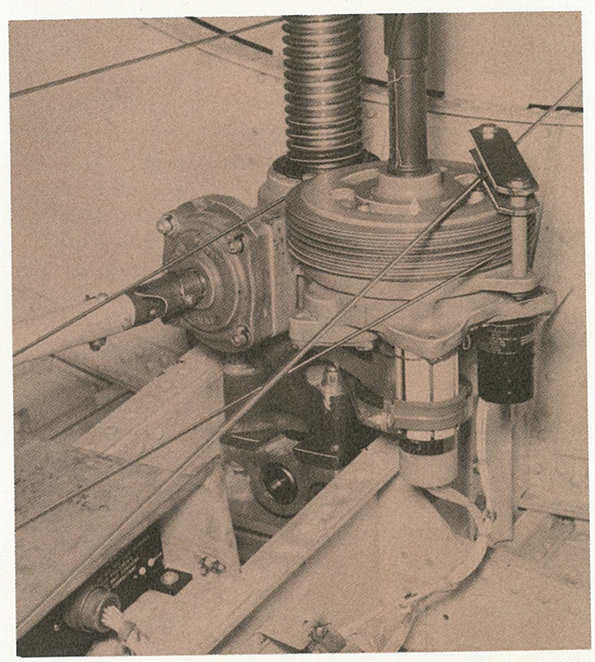
Emergency stabilizer trim makes use of an entirely different mechanism to move the screwjack upper gimbal. The input is via a mechanical torque tube linkage, direct from the flight compartment to the screwjack lower gimbal. Two means are provided for operating the torque tube, one electrical and one manual. A 110-volt AC motor is geared to the torque tube; the motor switch is on the center pedestal. If the motor for some reason fails to operate, the stabilizer can literally be cranked up or down by either pilot. A pair of trim wheels with attached handles is mounted on the pedestal just below the normal trim wheels.

Whether turned manually or by motor, the torque tube, at the screwjack assembly, turns the screwjack itself, through a bevel gear at the lower gimbal. In order to operate the emergency system, hydraulic pressure must be cut off from the normal actuating mechanism. An emergency trim switch on the pedestal cuts off hydraulic power from the actuator and also arms the emergency trim motor.

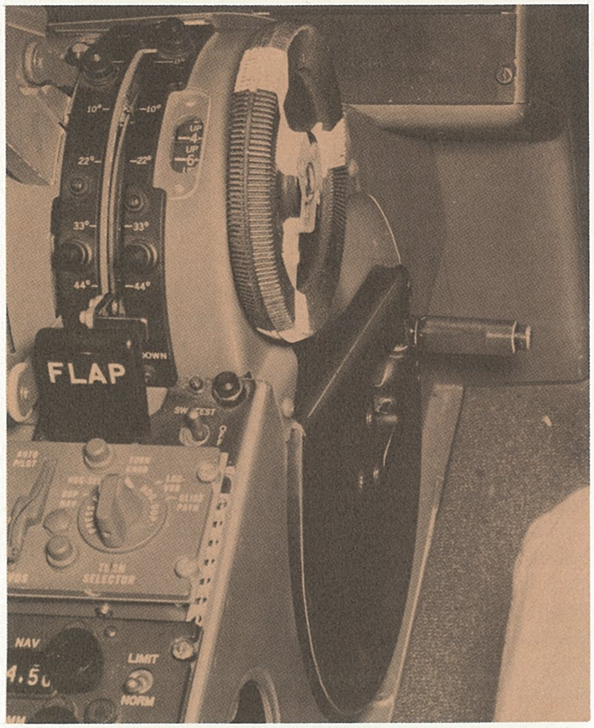
The worm gear drive on the traveling nut in the upper gearbox is irreversible. With hydraulic power cut off, the nut will be held from rotating by the worm, and will move up or down as the screwjack is turned. The emergency bevel gear in the lower gearbox is not irreversible, however; and to keep the Acme screw from turning during normal operation



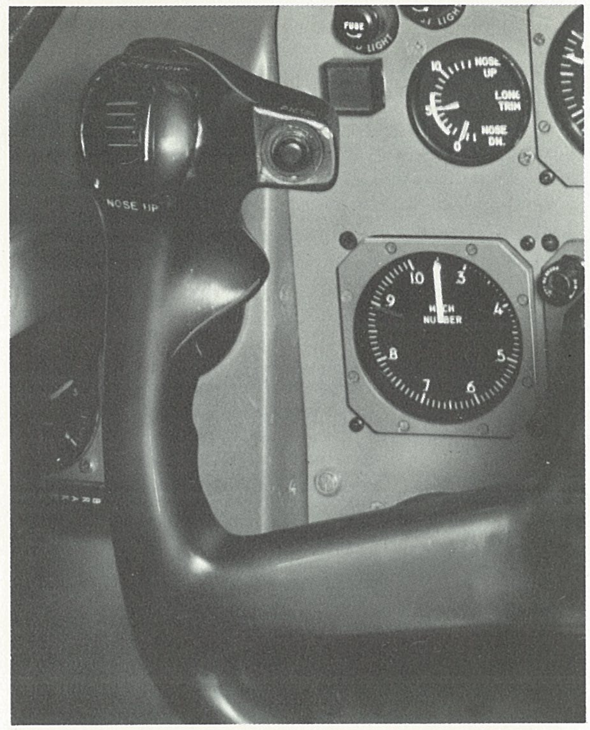
White (upper) arrow, on traveling nut housing, points to control valve, linked to helical control shaft assembly. Hydraulic motor is below and to the left.



Emergency trim "no-back" is at left. Harness links speed stability servo motor (black "can," below cable drum) and feedback potentiometer to amplifier.



Pedestal trim indicator and normal trim wheel are above. Below is emergency wheel with crank extended.



Beep trim button is on outboard horn of each control yoke. At right is the panel trim indicator.

of the traveling nut, a "no-back" mechanism is needed in the gear drive. The no-back is a bi-directional irreversible device in the lower gearbox and is attached at the end of the torque tube, with the bevel drive pinion gear as its output end.

With use of the electric motor, the stabilizer, under no load, can be moved at the rate of .1° per second. Manual emergency trim is slower. Full stabilizer travel represents 253 turns of the trim cranks; if the hand cranks must be used, the pilots must be prepared to allow extra time for large trim changes. Since the emergency trim wheels and the motor are both geared to the torque tube, the trim wheels will turn rapidly when the motor is used for emergency trimming.

On the pedestal beside each normal trim wheel there is a stabilizer position indicator that shows nose-up trim in degrees. These indicators are geared to the cable drum, and show trim input by the pilots or by the autopilot, whether through normal hydraulic actuation or by emergency system. In emergency trimming, when hydraulic power is cut off from the actuator, the servo valve is locked. Up or down travel of the upper gimbal therefore rotates the helical control shaft, thus feeding back stabilizer position through the cable system back to the pedestal position indicator.

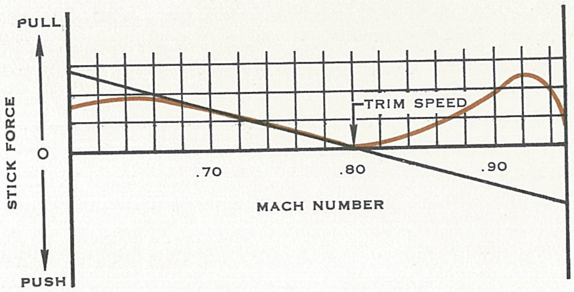
A separate position indicator dial is on the pilot's instrument panel. This is electrical, remotely-driven by a synchro transmitter mounted on fuselage structure in the tail cone. The synchro servo is operated by an arm attached to the stabilizer rear spar. Whereas the pedestal drum-type indicator shows only pilot or autopilot trim input, the panel dial shows actual stabilizer position, thus including the input from the speed stability system.

SPEED STABILITY SYSTEM

Explanation of the operation of the "880" speed stability system may be easier if prefaced by a short summary of basic aerodynamic factors peculiar to high-speed flight.

The Federal Aviation Agency requires that throughout an airplane's normal flight range, when it is trimmed for straight level flight at a certain speed, the airplane should, if put into climb or descent attitude, level off and return to within 10% of the trim speed, "hands off." Also, when trimmed for a certain speed, elevator control force should increase in a stable proportion to deviation from that speed; that is, the faster the airplane goes, the more push should be required for elevator control, and the slower it goes, the more pull should be required to hold nose up (longitudinal trim remaining unchanged).

Flight at high Mach numbers affects this stability adversely in nearly all high-speed swept-wing aircraft. Several varying factors are involved — sonic compressibility phenomena, airflow and flow separation, downwash, and flexibility and elasticity of airframe and airfoils. But, typically, the dominant factor is that wing center of pressure moves aft with increase in speed, causing a nose-down moment termed "tuck" or "tuck-under." An airplane trimmed for Mach .75 and speeded up to Mach .90 usually tends to nose down and pick up still more speed. Instead of requiring push on the stick to keep speed up, it requires a pull to keep speed down to Mach .90.



With airplane trimmed for Mach .80, black line represents desirable slope of stick force at other speeds; colored line is actual force required without speed stability input. With system operative, Mach .80 trim includes some Q-scheduled input. Added trim is removed as airplane slows, increased as speed increases, making ends of curve approach the theoretical optimum slope.

Most aircraft that fly in this transonic range (approximately Mach .80 to Mach 1.2) have some kind of automatic longitudinal trim device to compensate for tuck-under. The aerodynamic characteristics of a particular airplane determine how the device is tailored to meet the stability requirements.

Careful analysis of flight test data indicated that the "880" should have trim compensation for tuck-under at speeds exceeding approximately Mach .80. In flight training, pilots fly the "880" up to its never-exceed Mach number (Mach .89) without trim compensation, so they will "feel" the adverse control forces and know how much elevator pull force would be required in an emergency. Nevertheless, this necessary pull is inadmissible stability for transport aircraft, and "880" cruise speed is limited by the Flight Manual whenever automatic trim compensation is unavailable.

Within the range of "880" flying speeds, there exist other factors that cause variation from an ideally linear relationship between airspeed and stick force. This is due in part to the width of the airspeed range — from approximately 112 kts to 535 kts — and partly to the individual aerodynamic characteristics of the "880." In the flight test program, it was demonstrated that a better curve of stick force vs airspeed could be obtained if a certain amount of nose-up trim were added below Mach .80, programmed by "Q" pressure rather than by Mach number.

Consequently, a system was developed to provide automatic nose-up trim at approximately 200 kts CAS, increasing to a maximum of 3.7° of stabilizer travel at 440 kts CAS and Mach .91. These limits are well beyond "880" prescribed never-exceed speeds. The mechanism by which this is done is as follows:

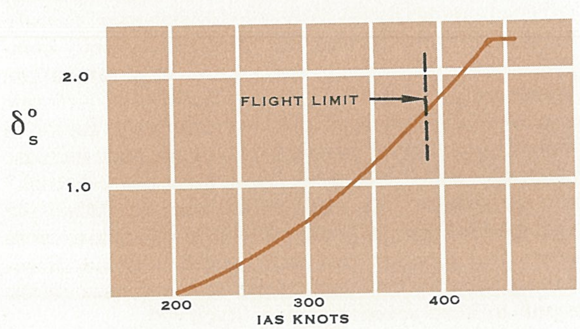
The trim input is added by a small servo motor mounted under the cable drum in the lower gimbal. The planetary gear assembly that drives the helical control shaft functions also as a differential; the shaft can be rotated either by the cable drum or by the speed stability servo motor, or by both at once. Stops in the gear assembly limit speed stability system travel to approximately 193° of shaft rotation, equivalent to 3.7° of trim.

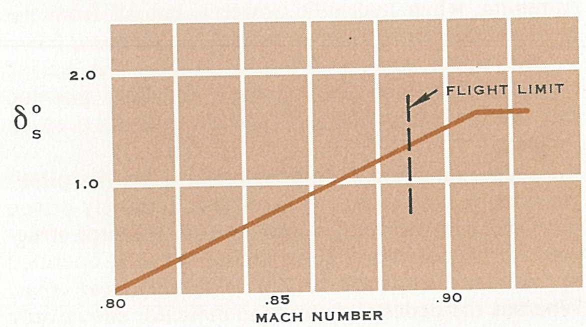
The power that drives the motor is from an amplifier mounted just forward of the screwjack. Amplifier output is determined by two inputs, one governed by indicated airspeed and the other by Mach number.

The airspeed input comes from a "Q" transducer, located just below the flight compartment in the copilot's pitot-static system. The Mach signal is supplied by a synchro servo governed by a special potentiometer in the KIFIS (Kollsman Integrated Flight Instrument System) computer in the electronics compartment. Effective "Q" transducer signal begins at 200 kts IAS, Mach signal at Mach .8. A feedback potentiometer, mounted below the cable drum, is geared, like the motor, to the speed stability gear of the differential. It provides gear position feedback to close the servo loop and cut off power to the motor when the position programmed by "Q" pressure and Mach number is reached.

Maximum "Q" trim is 2.3° of stabilizer travel; maximum Mach trim is 1.6°. This, it will be noted, adds up to slightly more than the 3.7° possible automatic trim. Graphs accompanying this article show the input curves from each source.

There is also published herewith a table showing the amount of automatic trim in several combinations of airspeed and Mach number. Although these data are not included in the FAA Flight Manual, they may be useful at times for in-flight check of the operation of the speed stability system. It is necessary only to observe the difference between the stabilizer position indicators on the pedestal and on the instrument panel; the difference between the readings is the speed stability system input. This should agree with the table within .25°. It is, of course, not possible to read the position indicators within the .01° increments of the table, but it should be possible to determine if the





KNOTS	Below .80	.82	.84	.86	.88	.90
	MACH NUMBER					
Below 200	0.00	.29	.58	.87	1.16	1.45
240	.20	.49	.78	1.07	1.36	1.65
280	.48	.77	1.06	1.35	1.64	1.93
320	.85	1.14	1.43	1.72	2.01	2.30
360	1.27	1.56	1.85	2.14	2.43	2.72
400	1.74	2.03	2.32	2.61	2.90	3.19

"880" SPEED STABILITY SYSTEM GAINS

difference in the readings is within the quarter-degree tolerance.

With the system inoperative, flight maximums are 335 kts CAS or Mach .73 (375 kts CAS or Mach .78 in emergency descent). If necessary, the elevator provides sufficient "authority" to counteract 3.7° of stabilizer trim, and the normal trim system should still operate through the cable drum.

The Mach trim part of the system is normally checked during preflight by use of the KIFIS test button. This feeds a signal into the speed stability amplifier, which should cause the stabilizer to move the full Mach-programmed 1.6° travel.

In connection with preflight checks, it may be noted that the beep trim switch should not be used in checking stabilizer operation on the ground when the hydraulic system has no source of power other than the airplane electrically-powered hydraulic pump. With sufficient hydraulic power supply, the stabilizer will move fast enough to keep up with beep motor demands. The standby electrical pump, however, does not provide enough hydraulic power to move the stabilizer at the full rate.

The beep trim motor will then do one of two things: 1) If the speed stability and/or flight instrument circuit-breakers are open, it will overrun the cable drum differential and drive the speed stability servo motor backwards at a velocity approximately three times normal, shearing or jamming the servo motor pinion when the speed stability stops in the drum contact. 2) If speed stability and flight instrument circuit-breakers are closed, it will slip the clutch in the beep trim motor and cause decay in its torque output setting.

Emergency system preflight checks should be limited to between 1° and 13° nose-up trim, to prevent inadvertent contacting of upper and lower torque stops on the stabilizer screwjack.

SAFEGUARDS AND WARNING SYSTEM

The screwjack assembly and control system have been designed with every failsafe feature practicable for such a vital mechanism. Both screwjack and helical control shafts have inner safety shafts in case the outer shaft fails structurally. There are multiple stops in every actuation system — on the shafts, in the control valve assembly, in the cable drum differential gears, and on the cables.

Pilot training always includes some drill in dealing with a "runaway" stabilizer, that continues to move in spite of pilot effort to control it. As of this writing, there have been no instances reported of this occurring in an "880" in service. In fact, there have been no occasions when manual emergency trim was required. It may, however, be of interest to indicate what can be done in the event of a runaway or jammed stabilizer.

In any normal trim regime — manual, beep system, or autopilot — the hydraulic motor can be stopped by lifting the guard over the STAB TRIM HYD SHUT-OFF switch on the center pedestal, and actuating the switch to CLOSED. This will stop a "runaway" from either electrical or mechanical causes. Should the normal trim wheel be turning, it can be stopped by hand. The malfunction in such a case would probably be electrical, from contact failure in beep trim or autopilot circuits; and the beep and autopilot trim motor forces on the rim of the normal trim wheel are only approximately six pounds, which can easily be counteracted. If the trouble is determined to be in the beep trim circuitry, the STAB TRIM CONT circuit-breaker should be deactivated. Then, if desired, the hydraulic shutoff can be reopened and pitch trim resumed by the normal trim wheel.

A dual failure in the follow-up linkage or hydraulic valve failure could conceivably cause a runaway, in which case the emergency trim system must be used.

A runaway emergency trim motor would be difficult to halt by forcibly stopping rotation of the emergency manual trim wheels, since the motor applies a force of approximately 75 lb. at the wheel handle. Usually, the best way to deal with this situation would be to return the hydraulic cutoff switch to OPEN position, *provided* that the original malfunction requiring use of emergency trim was such that reopening the hydraulic valve will not cause additional difficulties. Pulling the STAB TRIM CONT EMER circuit-breaker will have the same effect, including reopening the hydraulic valve.

Emergency trim runaway situations would require multiple malfunctions and are statistically improbable. There is, nevertheless, a final backup for emergency pitch trim, making it possible to land the airplane with the stabilizer jammed in any position from full up to full down. Raising outboard spoilers provides considerable pitch-up moment; raising inboard spoilers provides pitch-down moment. The control is a switch on the pedestal that deactivates one or the other pair of spoilers, allowing extension to the desired deflection by use of the speedbrake handle.

The speed stability system is monitored by an electronic device. If the error signal in the servo loop exceeds a normal operating level, or if there is a power failure, a red light illuminates in the flight compartment, at the top of the flight engineer's panel in some aircraft or on the pilot's instrument panel in others.

Takeoff trim varies from 1½° to 7° (2° to 6° in some aircraft) depending on airplane CG. If the stabilizer is not trimmed within this range, and any two power levers are advanced beyond 92% rpm while on the ground, the warning horn sounds intermittently. The actuating switch is part of the stabilizer position transmitter and is operated by a cam on the input arm.

CLEANING CABIN INTERIORS

Airplane interiors that are clean, sanitary and odor-free are important to the comfort and health of passengers. Since most maintenance cleaning is accomplished between flights, methods and materials that give the utmost cleaning value with a minimum of labor and equipment in a short period of time are desirable.

A knowledge of cleaning agents and their effect on different types of materials are essential to the proper treatment of soiled areas. The application of the wrong cleaning agent to a soiled spot may chemically set the stain or damage the material beyond repair.

Two types of stains are most frequently encountered in aircraft interiors — "built-up" stains (nail polish and food) that are usually nongreasy and tend to lie on the surface of the material; and "absorbed" stains (thin penetrating liquids) that are usually greasy and soak into the material.

Some stains, such as those caused by most foods, are both built-up and absorbed. These usually leave a dark color on the surface of the material. Most food stains can be identified by their tendency to turn a light color when the surface of the stain is scratched.

Built-up stains are usually the hardest and stiffest of the stains. They may be sticky or smooth, depending upon their origin. Food and ice cream spots generally leave irregular serrated edges that end abruptly and do not blend into the material.

Absorbed stains do not ordinarily affect the flexibility of the material. If they contain sugar, albumen, syrup, or dissolved starches, however, they may be a little stiff. Oil stains follow the weft of filler threads of the fabric and usually result in long narrow stains. Absorbed stains generally have feathered edges that blend into the material.

On the Convair 880/990 jet airliners, the following fabrics and materials are used in the cabin interiors:

Vinyl-coated glass cloth or cotton is used to cover all overhead, sidewall, and entryway panels, and vertical partitions. Certain decorative (accent) panels may be covered with polyplastex (laminated rigid vinyl).

Window rings and seat trim are formed of modified polystyrene (Boltaron or Royalite).

Nylon fabrics are used for upholstery on passenger seats.

Carpeting is of wool, with the exception of one airplane model which has nylon carpeting.

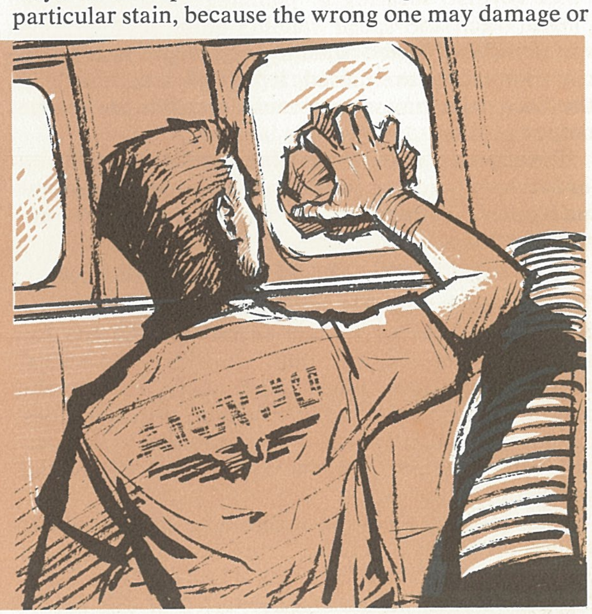
Arm rests and stewardess seats are covered with vinyl-coated jersey (Naugahyde or Fabrilite).

Most "absorbed" and "built-up" stains can be removed with four types of stain removers — absorbent materials or agents, detergents, solvents, and chemical stain removers.

Absorbent materials include powders (cornstarch, cornmeal, talc, and powdered chalk), absorbent cotton, sponges, cloths, and absorbent paper (towels, tissues, and blotters). These materials are used to soak up staining liquids before they soak into fabrics, and are also used to absorb stains as they are loosened by liquid stain removers.

Detergents, which include soaps and liquid detergents, are especially useful for removing most nongreasy stains. They are also effective on some greasy spots. Detergents loosen particles in the fabric, enabling the particles to be easily rinsed away.

Solvents for cleaning purposes come in several varieties, many of which are hazardous in one or more ways. It is important to use the right solvent for a particular stain, because the wrong one may damage or



change the appearance of the material being cleaned. If possible, it is best to try a small amount of solvent on a hidden portion of the fabric, or on a sample piece to be sure of the results.

An understanding of the danger of nonflammable solvents cannot be overemphasized. The toxic effect of some of these solvents could prove fatal to persons exposed to the vapors, if they are used in confined areas without adequate ventilation. Extreme caution must be exercised when using methyl chloroform, perchloroethylene, and trichloroethylene. Carbon tetrachloride is not recommended because of its cumulative effect on persons exposed to its vapors. The other nonflammable solvents, although toxic and dangerous, are safer to use because they are not cumulative.

Flammable solvents such as petroleum naphthas should also be used with care. Their vapors are not as toxic as are those of nonflammable solvents, but their use requires adequate ventilation. In addition to ventilation, persons using flammable solvents should keep the vapors away from open flames, and should safeguard against sparks such as from electrical equipment and static electricity.

Chemical stain removers that are suitable for removing nongreasy stains include acetone, rubbing alcohol, chemically pure amyl acetate, and turpentine. Extreme care must be exercised when using these solvents because they are flammable and poisonous.

Chemical stain removers for greasy stains include methyl chloroform, perchloroethylene, and trichloroethylene. These solvents are nonflammable but are extremely toxic. Of the flammable grease-removing solvents, petroleum naphthas are the most widely used. The naphtha solvents are not as toxic as are the nonflammable kinds, but they still have dangerous vapors and are highly combustible.

When spots cannot be removed by absorbents, detergents, or solvents, such chemical stain removers as bleaches, acetic acid, ammonia, iodine, oxalic acid, and sodium thiosulphate may be used. Fibers are more likely to be damaged by chemical stain removers than by any of the other removers. These removers, in particular, should be tested on samples of the material before trying to remove stains.

Bleaches, which include chlorine, sodium perborate, hydrogen peroxide, and color removers, are the most widely used of the chemical removers, and also the most likely to damage fibers and fade dyes, if not properly used. Directions peculiar to the different bleaches should be carefully followed.

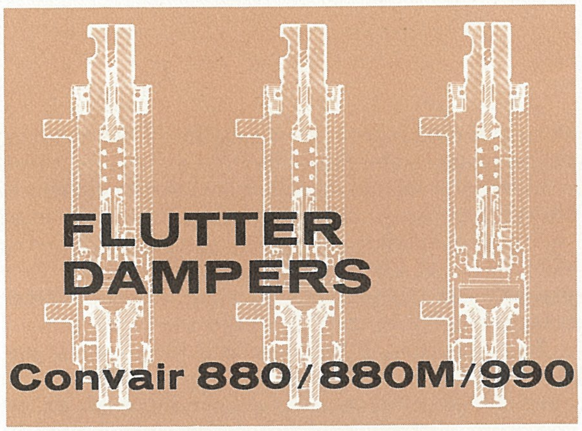
Since interiors of the Convair jet airliners are generally finished in plastic, the majority of stains may be removed effectively by using a clean soft cloth dampened with aliphatic naphtha. A dry cloth is used to wipe the area dry after the cleaning operation. It is especially important to test the solvent on a sample piece of material because some solvents could remove the decorative surface or design.

For the most stubborn stains on plastic surfaces, a clean cloth dampened with castile soap suds will usually clean the spot. The suds are afterwards removed by wiping the area with a soft cloth moistened with clean water.

In time, the overhead plastic panels may become discolored as a result of passenger smoking. To remedy this situation, a clear spray is being developed to seal and protect the surface of the panels. Tests conducted so far have indicated that approximately 95 percent of the smoke stain may be removed from coated plastic panels by washing with soap and water or with isopropyl alcohol. Uncoated panels are more difficult to clean, and the results are not always satisfactory. Additional information will be released through the proper channels when the smoke-resistant coatings and appropriate cleaning agents are available.

The upholstery and carpet fabrics are more susceptible to stain complications, especially of the absorbent types, than are the plastic surfaces. As a result, they will be subject to a greater variety of cleaning agents and techniques. The appropriate Maintenance Manual will give detailed cleaning instructions.

The Maintenance Manual also contains a list of recommended cleaning materials and the manufacturers.



FLUTTER DAMPERS

Convair 880/880M/990

Control surfaces of the Convair 880/990 jet airliners, with the exception of trim tabs and ailerons on the "880," and the rudder on the "990," are fitted with hydraulic dampers to counteract any fluttering tendencies that might occur during flight.

On the "990," a full hydraulically-powered rudder performs the same damping function as the flutter damper; hence, is not required on this surface. On the other hand, although equipped with rudder boost, the "880M" retains rudder and flight tab flutter dampers.

The "880" rudder is equipped with three flutter dampers — two at the upper portion, and one at the lower portion of the rudder. The dampers are mounted on the front rudder spar in line with the rudder hinge line. The rudder flight tab is also flutter-damped, with two units mounted one above the other aft of the front rudder spar. The upper flight tab damper is connected to the upper flight tab horn, the lower to the flight tab control rod.

The elevators on the "880" are equipped with a total of four flutter dampers — one mounted at the inboard end and one mounted at the outboard end of each control surface. The dampers are installed on the front elevator spar along the elevator hinge line. The damper arms are attached to the horizontal stabilizer structure in a manner that causes hydraulic action of the damper to prevent the control surface from fluttering under induced conditions.

Each of the "880" elevator flight tabs also have two flutter dampers. These are mounted on brackets fastened to the stabilizer structure at the aft inboard section of each horizontal stabilizer. The damper arms are connected to the flight tab bellcrank arms.

The "990" elevator and elevator flight tab flutter dampers are much the same as those of the "880" with the exception of a third damper installed on each elevator. This additional flutter damper is mounted at the outboard end of the elevator.

Two flutter dampers are installed on each "990" aileron, along the aileron hinge line. The arms of the dampers are attached to the wing structure.

Flutter dampers are also fitted to each of the "990" aileron flight tabs. The arm of the outboard damper is connected to the flight tab control rod, while the arm of the inboard unit is connected only to the flight tab.

The "880" ailerons and aileron flight tabs were originally equipped with flutter dampers but, at the completion of a series of flight tests, the dampers were deemed unnecessary and removed.

The hydraulic flutter dampers installed on the Convair jet airliners are of the rotary type. They consist of a hollow cylinder, a hollow shaft fitted with a damper arm, and a reservoir for hydraulic fluid with a spring-loaded piston in one end. The spring-loaded piston forces fresh hydraulic fluid from the reservoir into the hollow damper shaft as the need arises.

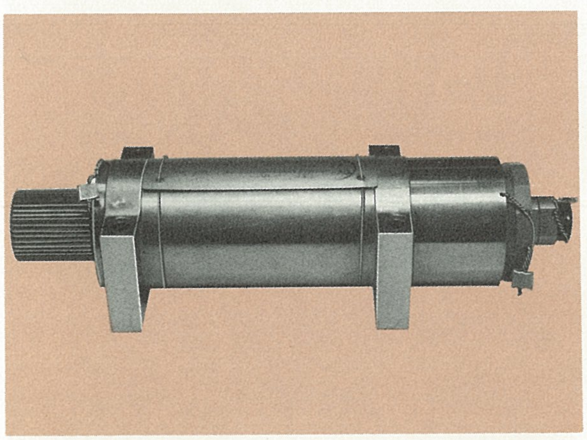
The cylinder of the damper is divided into six separate chambers by three stators inside the wall, and three vanes on the shaft. Each chamber is connected to the hollow shaft by a metering passage.

When the control surface is deflected, the damper cylinder rotates about the fixed hollow shaft, causing the stators to decrease the size of the cylinder chambers, forcing fluid through the metering passages and into the hollow shaft. During this action, fluid also flows from the shaft through remaining metering passages into the enlarging chambers behind the stators.

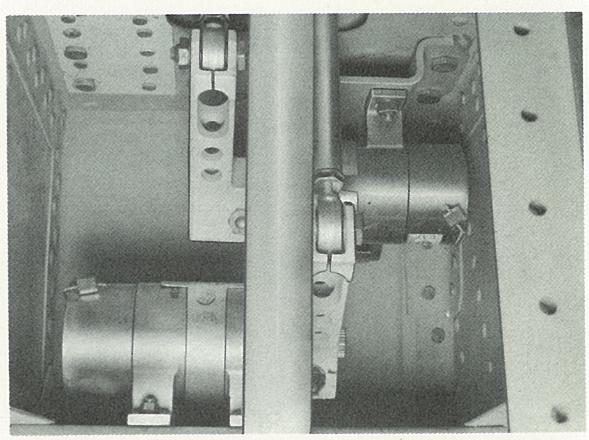
The size of the metering passages connecting the cylinder chambers to the hollow shaft determine the rate of control deflection. The passages are not so small that they interfere with normal control movements, but are small enough to damp any sudden movements that might develop into a flutter.

Each of the flutter dampers is provided with a filler cap for servicing, and a visual indicator to show the amount of fluid contained in the unit.

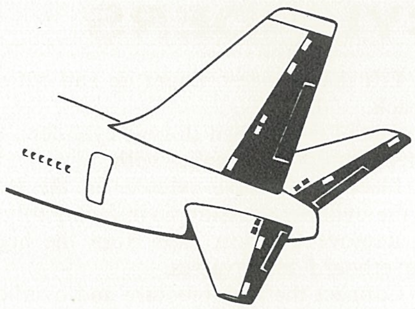
Location of flutter dampers is shown in the following chart for quick reference.



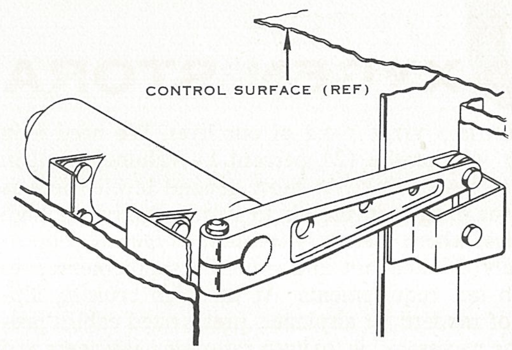
Typical hydraulic rotary flutter damper used on Convair jet airliners. "REFILL" cap on far right.



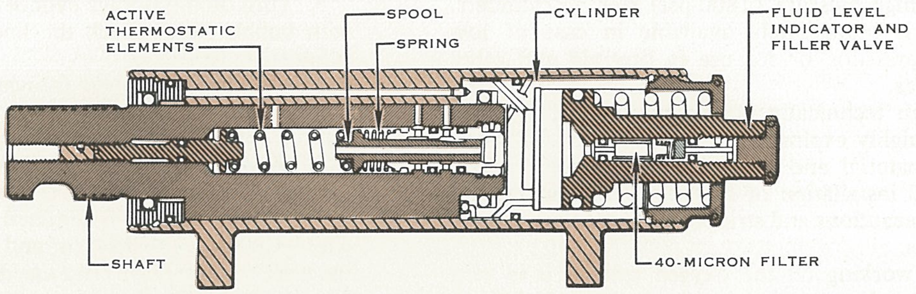
Two elevator flight tab flutter dampers installed on Convair 880. Units counteract fluttering tendencies.



FLUTTER DAMPER LOCATIONS (TYPICAL)



FLUTTER DAMPER INSTALLATION (TYPICAL)



CROSS SECTION OF ROTARY FLUTTER DAMPER

LOCATIONS OF FLUTTER DAMPERS

SURFACE	880/880M	990
AILERON	Removed after flight test.	One outboard, one inboard of each aileron. All are mounted on front aileron spar in line with aileron hinge. Damper arm is attached to wing structure.
AILERON TAB	Removed after flight test.	Mounted on bracket, aft of aileron front spar. Outboard damper is connected to flight tab control rod; inboard damper is connected to inboard flight tab.
ELEVATOR	One inboard, one outboard on each elevator. Each is mounted on front elevator spar in line with elevator hinge. Damper arm is attached to horizontal stabilizer structure.	Three on each elevator. All are mounted approximately in line with hinge line adjacent to No. 2, 5, and 6 hinges. Damper arm is attached to horizontal stabilizer structure.
ELEVATOR TAB	Two for each elevator tab. Each is mounted on a bracket attached to stabilizer structure at aft inboard section, and connected to flight tab bellcrank arms.	Two for each elevator tab. Each is mounted on a bracket attached to stabilizer structure at aft inboard section, and connected to flight tab bellcrank arms.
RUDDER	Two near top, one near bottom of rudder. Each is mounted on front rudder spar in line with rudder hinge.	Power rudder hydraulic cylinders on rudder act as flutter dampers.
RUDDER TAB	Total of two, one above the other. Each is mounted aft of front rudder spar. The upper damper is connected to the upper flight tab horn; the lower is connected to the flight tab control rod.	Not required with fully powered rudder.

OXYGEN STORAGE CYLINDERS

OXYGEN IS A VITAL PART of our lives. We need it in the air we breathe (21 percent by volume), and in the water we drink. At most ground levels there is sufficient oxygen in the air to sustain us, but at high altitudes, where the air is rarified, oxygen is proportionately thinned out and must be supplemented to furnish our requirements. At the high cruising altitudes of modern jet airplanes, pressurized cabins provide the necessary air/oxygen ratio for passengers and crew, or, in an emergency, regulated oxygen from storage containers.

In the Convair 880/990 jet airliners, oxygen is contained in high-pressure (1800-psi) storage cylinders, where it is immediately available in case of loss of cabin pressure, or for use in first aid and other emergencies.

Although technically nonflammable, pure oxygen becomes highly explosive when combined with combustible material and heat. For this reason, the removal and installation of oxygen equipment require definite precautions and strict compliance with certain procedures.

Before working on the oxygen system, it is very important to be sure that hands, tools, and clothing are free from grease, oil, and contaminants. It is also important that all oxygen pressure be bled from the system before loosening or tightening line fittings. The rapid escape of high-pressure oxygen generates heat, and contaminants, such as dirt or grease combined with oxygen, form the requisites for spontaneous combustion.

All valves in high-pressure oxygen lines should be opened and closed very slowly to prevent the generation of heat from pressure surges. All dust caps used to cap oxygen lines should be absolutely clean to preclude contamination of the oxygen system.

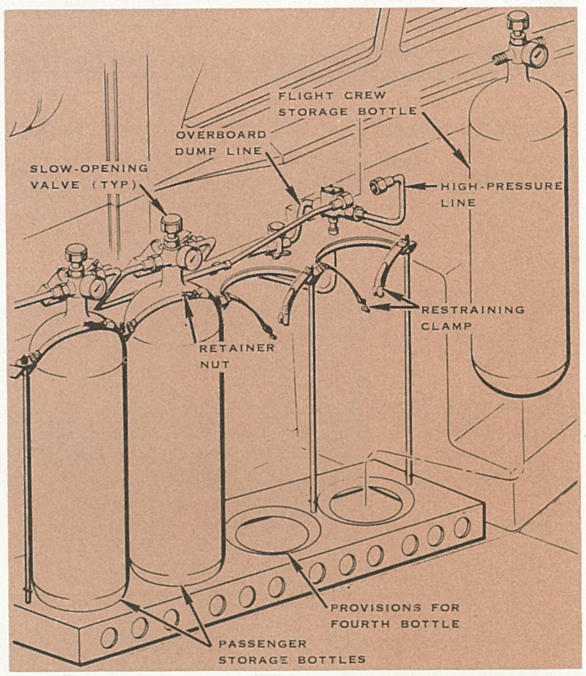
The oxygen storage cylinders on the Convair 880/990 are removed from the airplane for filling. When removing the cylinders, the following steps should be carefully followed:

1. Remove all electrical power from the airplane.
2. Ascertain that the oxygen storage cylinder slow-opening valve is turned off.
3. Loosen the nuts, and disconnect the high-pressure and overboard dump lines from the valve on the storage cylinder; cap all open lines and ports with clean dust caps.
4. Release the tension of the restraining clamp by loosening the retainer nut; pull out the safety pin, and release the clamp.
5. Lift the storage cylinder up and out of the storage rack.

To install the oxygen storage cylinders, the following steps should be complied with:

1. Place the storage cylinder in the storage rack with the cylinder pressure gage facing inboard.
2. Remove the dust caps from the high-pressure and overboard dump valves.
3. Connect the high-pressure and overboard dump lines to the fittings on the valve of the storage cylinder.
4. Connect the restraining clamp, tighten the retainer nut, and insert the safety pin.
5. Turn on the storage cylinder slow-opening valve; with bubble fluid, check the line connections at the cylinder for leaks.

Never lubricate oxygen fittings with lubricants containing hydrocarbons; use only lubricants meeting Specification MIL-T-5542B. Keep oil and grease away from all parts of the oxygen system. Allow adequate ventilation when purging the system, or when oxygen is being released into a confined area. Do not smoke when working with oxygen, and restrict personnel in the area to only those who are necessary for the performance of the task.



Convair 880/990 oxygen storage bottle installation.

VOLUME XIII NUMBER 8 DECEMBER 1961

Convair Traveler

In this Issue: The Stewardess and the Convair Jet Airliner

OUR COVER

Today's jet airline stewardess has become the symbol of grace and efficiency the world over. In keeping pace with the sophisticated jet age, she has lost none of her warm personality and tact. Artist — Harvey Adams.

Convair Traveler

VOLUME XIII NUMBER 8 DECEMBER 1961

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IN THIS ISSUE

A digest of operation and service published monthly by the Service Publications Sections of Convair Customer Service Department in the interest of Convair operators. Communications should be addressed to the Manager of Customer Service Department, Convair, San Diego 12, California. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without specific approval of their cognizant organization.

GENERAL DYNAMICS | CONVAIR

THE STEWARDESS . . .
and the Convair Jet Airliner

Take generous portions of efficiency, diplomacy and responsibility; mix in equal amounts of poise, charm and personality. Wrap in an attractive bundle weighing about 115 pounds and you have a modern airline stewardess.

ACCOMMODATIONS FOR THE COMFORT, convenience, and safety of crew and passengers are a result of the many features designed into the Convair 880/990 jet airliners. Utilization of certain equipment by the stewardess, and location of emergency equipment are planned for functional efficiency. This information, plus certain circumstances demanding action by the stewardess, is discussed since the best protection during an emergency is a knowledge of the equipment at hand and of its use.

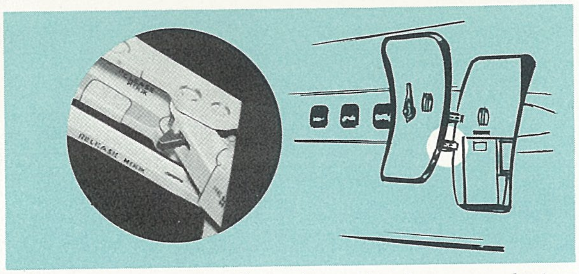
Airline stewardesses are graduates of airline-operated stewardess schools where they spend a jam-packed four to six weeks of intensive training, learning such subjects as Theory of Flight, the Art of Conversation, First Aid, and Baby Care. They also become thoroughly familiar with operations of their airline, and with passenger compartment systems and emergency procedures. Instances are on record where this knowledge and familiarity with equipment has contributed to the cool thinking and quick action of stewardesses during an emergency.

Three or four stewardesses are normally in attendance on Convair 880/990 jet airliner flights, the number depending on the policy of the airline and on the seating configuration of the airplane. Each stewardess is assigned specific duties, but quite often works with the others as an efficient team in preparing and serving food and beverages, and in performing various passenger services.

In addition to a thorough knowledge of routine assignments, the stewardess must be completely indoctrinated in the use of emergency equipment, and must be able to cope with unusual and trying situations.

There are six entrances on the Convair 880/990 — two main entrance (passenger) doors on the left side of the fuselage, two service doors opposite the main doors, and two emergency hatches on opposite sides of the fuselage over the wing.

The two main entrance doors and the two service doors are each equipped with a gust lock to hold them in the "open" position and prevent them from swinging during windy conditions. The gust lock (a hook on the lower hinge arm) must be disengaged before closing the door.



Gust lock prevents door from inadvertent closing.

To open the door from the inside, the stewardess must rotate the door handle counterclockwise until it is straight up. This action raises the wedge-shaped door free of its locking mechanism so that it can be pushed outward. The wedge design of the doors insures a positive seal which is essential in maintaining a pressurized cabin. When the door is closed, the handle is moved to the down position to insure a positive lock. If the door should ever become unlatched during flight, the stewardess must not attempt to close it, but should stay clear of the area, and notify the pilot of the condition.

Emergency escape hatches may be opened and removed either from inside or outside the airplane. For inside operation, the protective cover at the top of the hatch is pulled down to gain access to the latch handle. The handle is then pulled up to unlock the latching mechanism; the recessed handhold at the bottom of the hatch is grasped, and the hatch is removed by lifting upward and inboard. The hatch may then be disposed of by sliding it under a row of seats. To facilitate the operation, the center armrests of the seats just forward of the hatch are removed and the seat backs pushed all the way forward; the center armrest of the seats aft of the hatch are also removed to facilitate evacuation through the opening.

Door is opened by rotating handle counterclockwise.

Two public address (PA) control panels for the stewardesses are installed on Convair jet airliners. One is located adjacent to the forward stewardess seat in the forward galley; the other is near the aft stewardess seat in the aft galley. The panels are similar, having voice and music volume controls and pilot and stewardess (HOSTESS) call buttons, with the exception of the forward panel which has an additional control for operating the music reproducer. A telephone handset is mounted on a swivel door below each PA panel, and is used for both interphone and public address announcements.

With the handset removed from the holder and the PUSH PA button pushed to ON, the handset is connected to the PA system. (The music will automatically go off since it is overridden by the PA system.) To make an announcement, the operator need only to speak into the handset with the push-to-talk switch depressed. When the handset is replaced in the holder, the PA system is automatically switched off (music will resume), and the handset is automatically reconnected to the intercom system. On some Convair 990's, the stewardess has a separate hand-held microphone for transmitting messages over the PA system. The system is activated by the push-to-talk switch.

The normal position for the PA volume switch is LOW on the ground and HI in flight. Some configurations have a volume control knob that is normally set at 5 or 6 for average in-flight announcements, and at 8 or 9 during maximum noise conditions on the ground. The VU (volume) meter should be monitored while speaking over the PA system. The volume is satisfactory if the needle of the meter swings into the center of the dial.

The music controls on the forward PA control panel consist of an ON-OFF switch and a music volume control. A tape-reproducer music system is capable of playing continuously by automatic recycling of the tape after every sequence.

As stated previously, the music is overridden whenever an announcement is made over the PA system. The priority of command is as follows: the aft stewardess may override the music; the forward stewardess may override both the music and aft stewardess; the pilot may override the music and both stewardess positions.

Additional control panels for the stewardesses are located in the forward and aft galleys. The forward panel is installed above the forward service door; the aft panel is installed above the aft service door. These panels are equipped with call lights, circuit breakers, a hot water switch, and normal and emergency (on the 880 only) light switches.

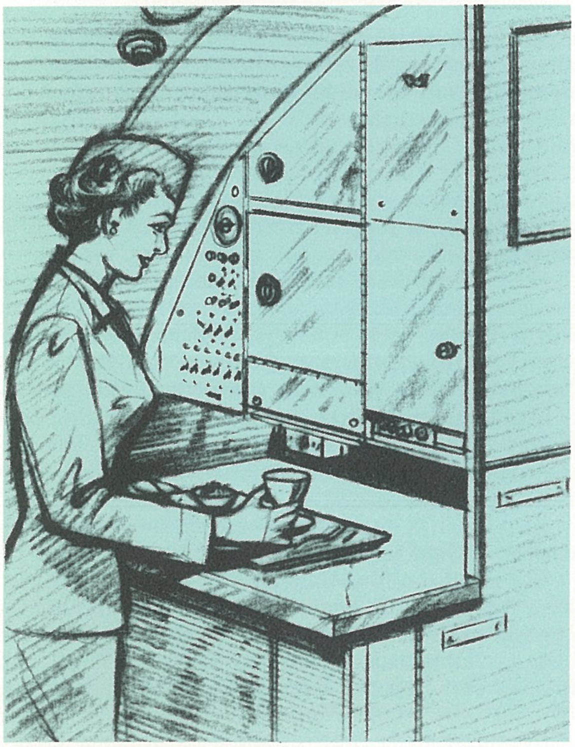
Stewardess control panel in aft galley (typical).

When a passenger pushes a call button, located in the convenience panel over each row of seats, the seat row number will illuminate, and the corresponding cabin section indicator light on the stewardess control panel (or panels) will illuminate and be accompanied by a single-stroke chime. The passenger call light is reset by pulling the call button.

If the stewardess wishes to call the flight compartment, she depresses the PILOT call button, which is spring-loaded to the OFF position. This action illuminates a white light and sounds a chime in the cockpit. If the pilot calls the stewardess, the PILOT light on the stewardess panels will illuminate and the stewardess chimes will sound. No resetting of the pilot call button is necessary; it goes off when either stewardess handset is lifted from its hook. When one stewardess calls another, the STEW indicator light on the called stewardess panel illuminates. A chime sounds at both stewardess positions when either stewardess call button is depressed.

The Convair 880 is equipped with three lavatories — one forward and two aft of the passenger compartment. The "990" has an additional lavatory forward. With the LAV light circuit breaker on, a single light over the commode is on at all times; a light on each side of the mirror illuminates when the lavatory door is closed. Each lavatory has a call button which, when pushed, will illuminate the appropriate LAV light on the stewardess panels, and will also sound a chime. The light is reset by pulling out the call button.

Emergency entrance to any of the lavatories may be gained by inserting a coin or knife blade in the notch in the "occupied" sign on the door, and sliding up the sign.



Buffet showing control panel at left (typical).

Two to four buffets are installed in the 880/990 jet airliners, the number depending on airline and seating requirements. One or two buffets are forward of the main passenger compartment, next to the forward service entrance; the others are located aft of the passenger compartment, next to the aft service entrance. The buffet light switches are on the corresponding stewardess control panel.

The doors of the buffets must be closed during takeoff and landing. The auxiliary work tables for the buffets must be stowed and secured on clips and retained by straps; the work table for the forward buffet is stowed in the forward coat compartment, and the aft buffet work table in the aft coat compartment.

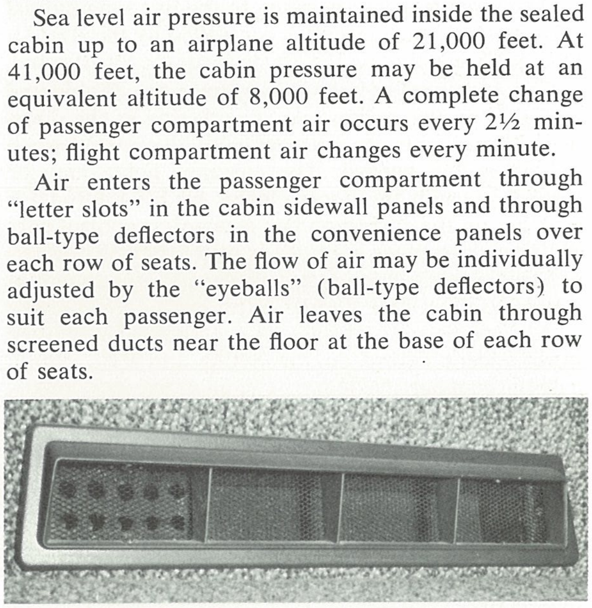
On some airplanes, carts are provided as an aid in serving food and beverages. The portable carts are to be folded when not in use. The carts and cart shelves are stowed and secured in a coat compartment for take-offs and landings.

The coat compartment arrangement on the 880/990 varies with different airline requirements; on most configurations, there are four. There are usually one or two coat compartments forward of the passenger cabin, and one or two aft of the passenger cabin. On some configurations, one or more coat compartments are a part of the class dividers. Some are equipped with conventional hanger rods, while others have telescoping rods. The telescoping rods are extended by depressing the button on the end. Plug-in trays for the first row of passenger seats and for the lounge seats (on some configurations) are stowed in the coat compartment.

The air conditioning and pressurization system enables passengers and crew members to travel in comfort. The pressurization system consists of two independent units; one unit directs supply air to the pilot and passenger compartments, the other to the passenger compartment only. Each unit is capable of pressurizing both compartments, should one of the units fail.

Sea level air pressure is maintained inside the sealed cabin up to an airplane altitude of 21,000 feet. At 41,000 feet, the cabin pressure may be held at an equivalent altitude of 8,000 feet. A complete change of passenger compartment air occurs every 2½ minutes; flight compartment air changes every minute.

Air enters the passenger compartment through "letter slots" in the cabin sidewall panels and through ball-type deflectors in the convenience panels over each row of seats. The flow of air may be individually adjusted by the "eyeballs" (ball-type deflectors) to suit each passenger. Air leaves the cabin through screened ducts near the floor at the base of each row of seats.



Temperature sensor is perforated unit in duct.

A temperature sensor for controlling cabin air heating and cooling is located in the duct on the right-hand side of the airplane, two seat rows forward of the emergency hatch. A true temperature indication is necessary for a comfortable cabin environment, and obstruction of the temperature sensor will result in the erroneous operation of the air conditioning system. Thus, it is important that this area remain free from objects such as coats, blankets, pillows, etc., that could block the normal operation of the sensor.

The stewardess has no control over the cabin air temperature or pressure. Cabin pressure controls are operated from the flight engineer's panel.

Most of the lighting in the passenger compartment, galleys, and lavatories is controlled by switches on the stewardess panels. General cabin lighting consists of fluorescent lights located in the coving on some configurations, and window lights in the valance directly above the windows on others. Control of these lights consists of ON-OFF and DIM-BRT switches at both forward and aft stewardess panels. On some airplanes, the degree of light intensity can be controlled by the length of time the DIM-BRT switch is toggled in the DIM or BRT position. Override switches in the pilots' compartment must be on before the cabin light switches can be operated.

On those aircraft with a lounge, the area is lighted by overhead lights and/or a table lamp. The lounge lights are controlled by the LOUNGE ON-OFF switch on the forward stewardess control panel. The table lamp has a switch on the top of the lamp shade.

The aisle lights on the cabin ceiling are controlled by a two-position toggle switch on each stewardess panel. These lights serve as a night light when the cabin general lights are off and the compartment is darkened for passenger sleeping.

Individual reading lights in the overhead convenience panels have push button switches beside each light for individual control. The reading lights are on five circuits, corresponding to the five longitudinal rows of seats; each circuit is controlled by the READING LT'S switches on the aft stewardess control panel.

The passenger entrance door areas are illuminated by lights on the ceiling and at each side of the doorway. These lights are automatically illuminated when the doors are opened. The entrance lights may be turned on, with the doors closed, by ENT ON-OFF switches on the corresponding stewardess control panels. Each passenger entrance is also provided with an external electrical power receptacle for attachment of a light to illuminate the passenger ramp.

A single fluorescent light fixture on the 880 and an incandescent fixture on the 880M and 990, illuminate the coat compartments. The lights are individually controlled by a sliding ON-OFF switch on the side of the compartment.

The buffet area lights are in the ceiling above each buffet, and are controlled by corresponding switches on the forward and aft stewardess panels.

Emergency lighting is provided in strategic locations throughout the interior of the 880/990. An emergency light is over each door and exit, over the aisle between the forward main entrance and forward service doors,

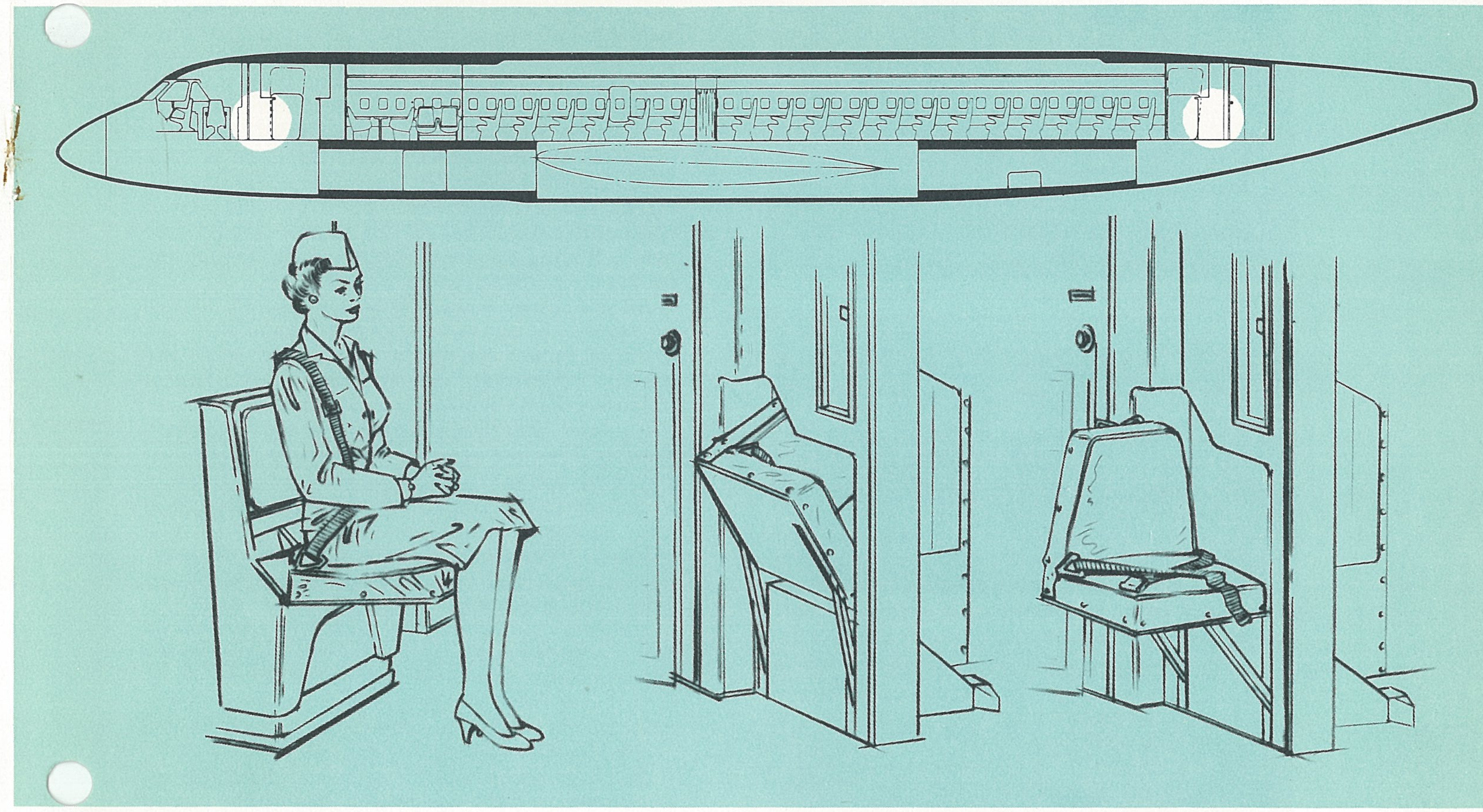
Food tray drops in position from forward seat back.

and over the aisles between the aft main entrance and aft service doors. There are also two emergency white dome lights in the pilots' compartment. Switches for the emergency lights are in the pilots' compartment, and on the forward and aft stewardess panels of the Convair 880. The stewardess emergency light switches are two-position ON-OFF toggle switches, and are used only for turning on cabin emergency lights. Two emergency lighting inertia ("g") switches, installed in the 880 and 880M pilots' compartment, will illuminate these emergency lights at an impact of 1.5 g's or more. Power for the lights is always available from the aircraft battery, regardless of the position of the battery switch and of the availability of emergency DC power.

The Convair 990 has AC-operated relays that perform a function similar to that of the "g" switches in that emergency lights are automatically energized if all AC power is lost.

Aircraft with overwater equipment have a portable emergency light at each exit.

The seats on the Convair 880/990 jet airliners have been designed for maximum safety, utility, and comfort. The passenger seats are equipped with seat belts, reclining backs, built-in armrests, ash trays, and integral seat back food trays. The armrests between the seats may be removed, if desired. When seat belts are required to be worn, passengers holding infants should hold them in arms — never under their belt.



Forward cabin attendant's seat is spring-loaded, folds down from galley bulkhead near forward service door. Aft attendant's seat hinges out from receptacle in wall near aft lavatory entrance, latches into position.

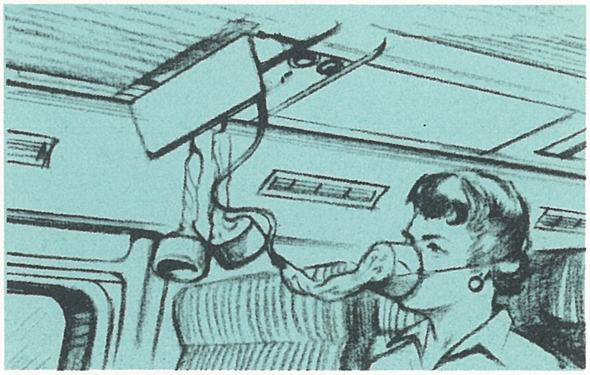
The lounge seats are not reclinable and do not have integral trays. Plug-in trays for these seats are stowed in compartments directly in front of the lounge on both sides of the galley partition, or in portable containers that rest on the floor.

Stewardess seats are located in the forward and aft galley areas. They fold into adjacent partitions when not in use. Each stewardess seat and the seats of the other crew members are equipped with shoulder harnesses as well as seat belts. The forward seat is spring-loaded to the UP position; the seat back and headrest are stationary on the bulkhead. The aft seat, with seat back attached, is hinged to drop sideways into position in front of the lavatory door. This seat is released for stowing by releasing a catch at the base of the seat back on the right-hand side.

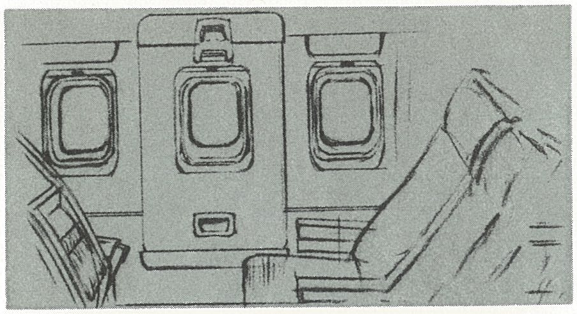
The Convair jet airliners are equipped with a high-pressure, 1800-psi gaseous oxygen system that is immediately available to all occupants of the airplane in the event of cabin pressure failure. The main oxygen supply storage cylinders are installed on the left side of the flight compartment, aft of the pilots' console. Each cylinder has a capacity of 74 or 107 cubic feet (depending on airline requirements).

Each passenger position has an oxygen mask stowed directly overhead in the convenience panel. Masks automatically drop down in front of each passenger whenever cabin pressure reaches 14,500 (±500) feet. Oxygen regulation and flow are automatic, as soon as the mask is pulled into position by the passenger. Passenger type masks are also located in each lavatory and at each stewardess seat. In some configurations of the Convair jet airliner there is a passenger-type mask installed in the flight compartment for the observer.

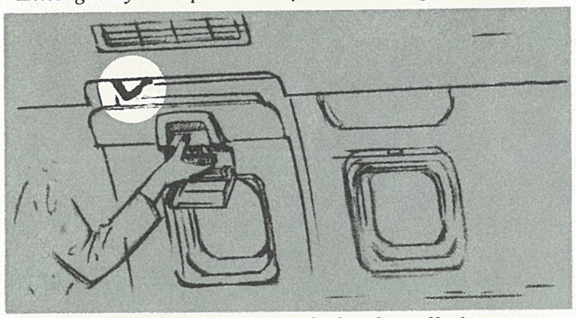
The pilots and flight engineer, and the third pilot in some cases, are supplied with a diluter-demand type oxygen system, permitting individual crew members to manually select either diluted or 100 percent oxygen. Their stations are equipped with half-face oxygen masks and either goggles or full-face smoke masks.



Passenger oxygen mask drops from convenience pod.

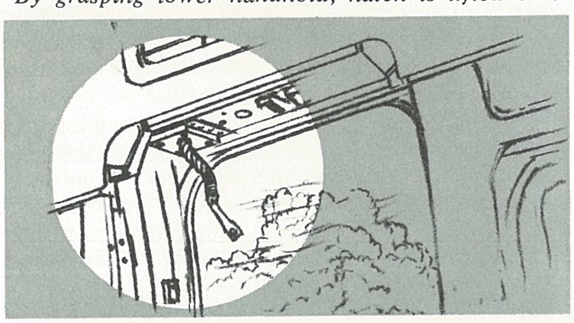


Emergency escape hatch for overwing evacuation.

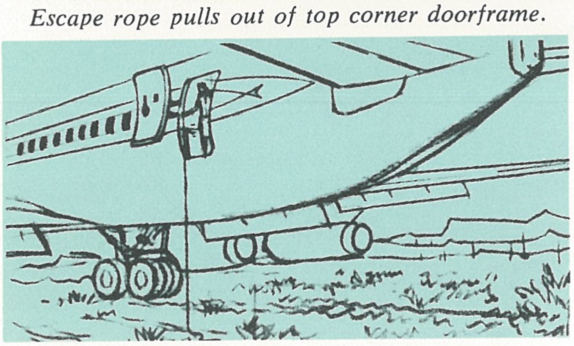


Protective cover is opened, latch pulled up, out.

By grasping lower handhold, hatch is lifted out.



Escape rope pulls out of top corner doorframe.



Loose escape rope may be fastened to doorframe.

First-Aid oxygen for passengers, plus a supplemental portable supply for stewardess and flight crew use, is provided by several portable oxygen cylinders that are located in the passenger and flight compartments. All crew portable oxygen cylinders have one full-face mask for protection against toxic conditions; passenger portable cylinders have from one to three continuous-flow rebreather disposable masks, depending on airline requirements. Some portable oxygen equipment is also furnished with demand-type full-face masks. Placing the control handle in the ON position readies the portable system for use.

All emergency equipment is conveniently located for expeditious use, and is well marked and placarded to aid in correct deployment and/or use. Drills and constant reviews keep the stewardess keyed to instant action, should an emergency condition arise.

All doors, with the exception of the overwing emergency hatches, are equipped with escape slides to expedite evacuation of passengers and crew in the event of an emergency. Evacuation slides are discussed in detail on pages 10 and 11.

Escape ropes are furnished at overwing emergency hatches and over the pilots' windows as an additional aid to rapid evacuation of the airplane. On some configurations, a loose rope is stowed in the forward coat compartment for use in climbing down from the main entrance door. With the emergency hatch removed, a red tape attached to the rope is exposed in the upper frame. The rope can be pulled down to aid in climbing down from the wings.

On aircraft scheduled for overwater flights, an adequate number of life jackets and life rafts are carried aboard to accommodate passengers and crew. Individual passenger life jackets are stowed in the pouches under each seat. Crew life jackets are stowed in the pilots' compartment, and in the forward and aft galleys.

A total of five life rafts — four 25-man and one 10-man — are available in case of ditching. A typical installation consists of two 25-man rafts on the floor of each of the class dividers (coat compartments), and a 10-man raft in the lounge area under the right-hand forward-facing lounge seat.

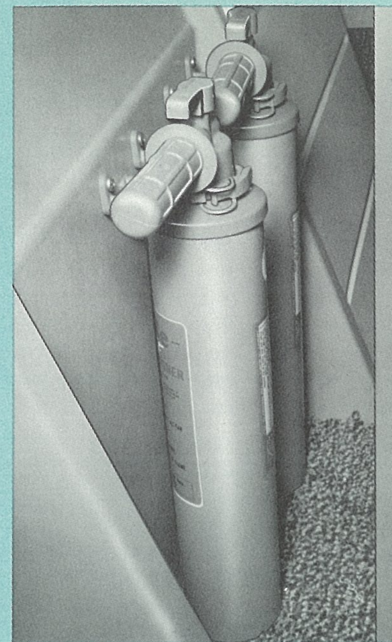
A fire axe is furnished as part of the emergency equipment on all airplanes. The axe is mounted on the forward side of the flight compartment door.

Both carbon dioxide (CO_2) and water-type (H_2O) fire extinguishers are provided for extinguishing different types of fires. The location of the extinguishers varies with different airline requirements, but there are adequate units distributed throughout the passenger and flight compartments. The fire extinguishers are secured by quick-release clamps to expedite their removal.

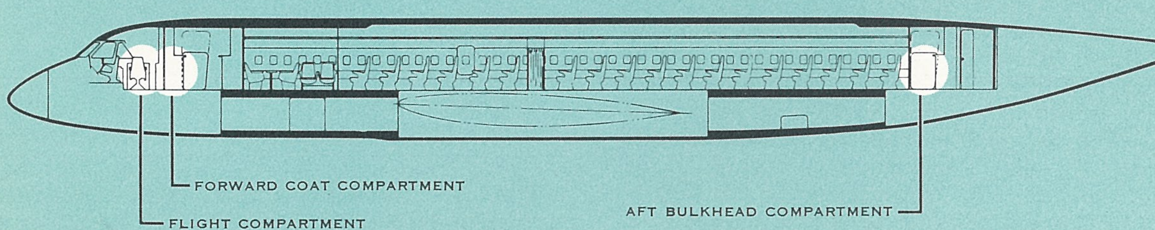
Carbon dioxide (CO_2) is a fast extinguishing agent that is used on small flammable liquid and electrical fires. It leaves no after-fire residue and is harmless to materials and equipment. It combats fire by reducing the oxygen content around the fire, thus smothering the flame. For this reason, care must be taken when using CO_2 in closed areas, because the diminished oxygen supply could cause anoxia. Most carbon dioxide cylinders are equipped with a horn and pistol grip

CO_2 BESIDE THE FLIGHT ENGINEER.

H_2O IN FWD COAT COMPARTMENT.



H_2O IN AFT BULKHEAD COMPARTMENT.



Adequate fire extinguishers are located throughout flight and passenger compartments, ready for instant use. Carbon dioxide (CO_2) is for flammable liquid, electrical fires; water (H_2O) is for wood, cloth fires.

handle. The horn is raised and aimed at the base of the fire, and the trigger is squeezed on the handle to activate the cylinder. The extinguisher should be recharged after each use. Because of the extreme low temperature of the gas while being discharged, the horn should not be used as a hand grip.

Water type fire extinguishers are used on wood, paper, and cloth fires. Water cylinders usually have a perpendicular carrying handle that must be turned on (screwed in by hand) to ready the extinguisher for use. Pushing down on the lever at the top of the cylinder emits a stream of water that lasts 30 to 45 seconds and has a range of more than 20 feet.

The water cylinder is actually charged with 1⅜ quarts of anti-freeze solution; however, the unit after discharge may be refilled in flight with tap water. This is done by unscrewing the carrying handle, inserting a new CO_2 cartridge with the head of the cartridge at the open end of the handle, and filling the cylinder with tap water. The handle is then screwed into the valve body until the red lines on the units are alined.

A first-aid kit is carried on all airplanes. It is usually located in the storage compartment of the aft coat closet nearest the aft main entrance. A quick-release clamp permits immediate removal.

All loose gear is carefully stowed during takeoffs and landings and when a ditching or high impact landing is anticipated. In case of an emergency landing, blankets, pillows, coats, and any other cushioning objects are distributed so that they can be bundled in front of the passengers for added protection.

On the back cover is a list of aeronautical words and phrases that are most likely to be encountered by a jet-age stewardess during the course of her duties. It may also serve as a source of reference for stewardesses desiring to obtain a speaking knowledge of flight crew jargon for the benefit of impressing inquisitive passengers.

Inflatable Evacuation Slides

How to evacuate an airplane load of passengers and crew members in a minute and a half was capably solved with the development of the escape chute, or slide. Slides have proved much more expeditious than conventional stairs or rope ladders, and enable evacuees to leave the airplane and reach the ground in safety and in record time. By "scooting" down the slide in a sitting position, reminiscent of childhood days, passengers suffer little more than ruffled dignity.

The FAA requires that all occupants of an airplane must be able to evacuate in the maximum time limit of 90 seconds in the event of a ground accident or a ditching. Tests have proved that, by using an inflatable escape slide, as many as 55 persons may safely evacuate from one entrance in 90 seconds.

There are generally four escape slides — one for each doorway — carried aboard the Convair 880/990 jet airliners. Usually, two of the slides are of the inflatable type — one for the forward main entrance, and one for the rear main entrance. They are stowed in a partition beside each of the doorways, and are immediately available for use in case of emergency ground evacuation or ditching. The evacuation slides available at the two service doors may be either the inflatable or noninflatable type, depending on customer requirements.

The inflatable escape slide is secured to a panel that is hinged at the floor. When the panel is opened, it drops across the threshold. The web-straps of the slide are attached to the left and right sides of the door frame by securing the red and green hooks to the correspondingly colored fittings on the door frame. Rolling the bundle out the doorway and pulling the T handle at the top of stowage compartment releases compressed air from the air bottle. Through the action of the compressed air and a jet pump, the slide is rapidly and automatically inflated to a pressure of 2 psi. As a safety feature, the system is designed to furnish a slow bleed of air into the slide to compensate for possible leaks. A relief valve in the system precludes the possibility of overinflation or rapid pressure rise.

No attendants are required to steady the lower end of the inflated slide. As many as three persons, weighing 200 pounds each, may be on the slide at the same time. The sliding surface is treated with an anti-friction agent to reduce friction and static electricity and speed up the occupant's descent. The slide will remain slippery, regardless of weather conditions.

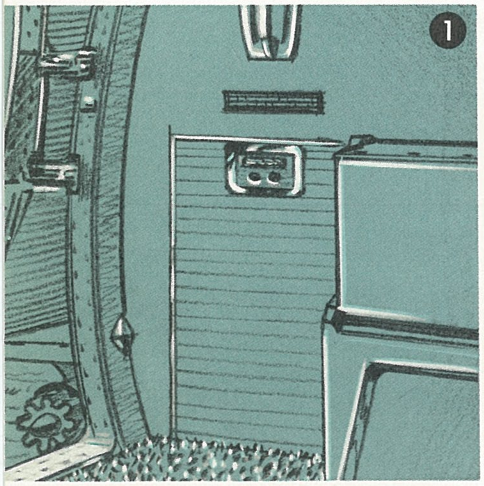
The inflatable slide may be quickly detached from the door frame and used as a life raft, in case of ditching. It has a buoyancy of 3400 pounds and is capable of supporting up to 20 persons. Adequate flotation handles are provided on both sides of the slide as hand holds.

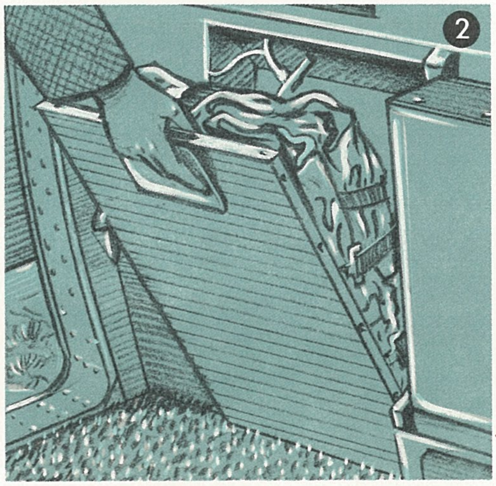
The inflatable escape slide is constructed of neoprene-coated nylon and rubber. An air-inflated tubular girder with two pneumatic guide rails, approximately 15 inches apart, form a rigid trough between the airplane and the ground. Reinforcement is provided in areas subject to abrasion.

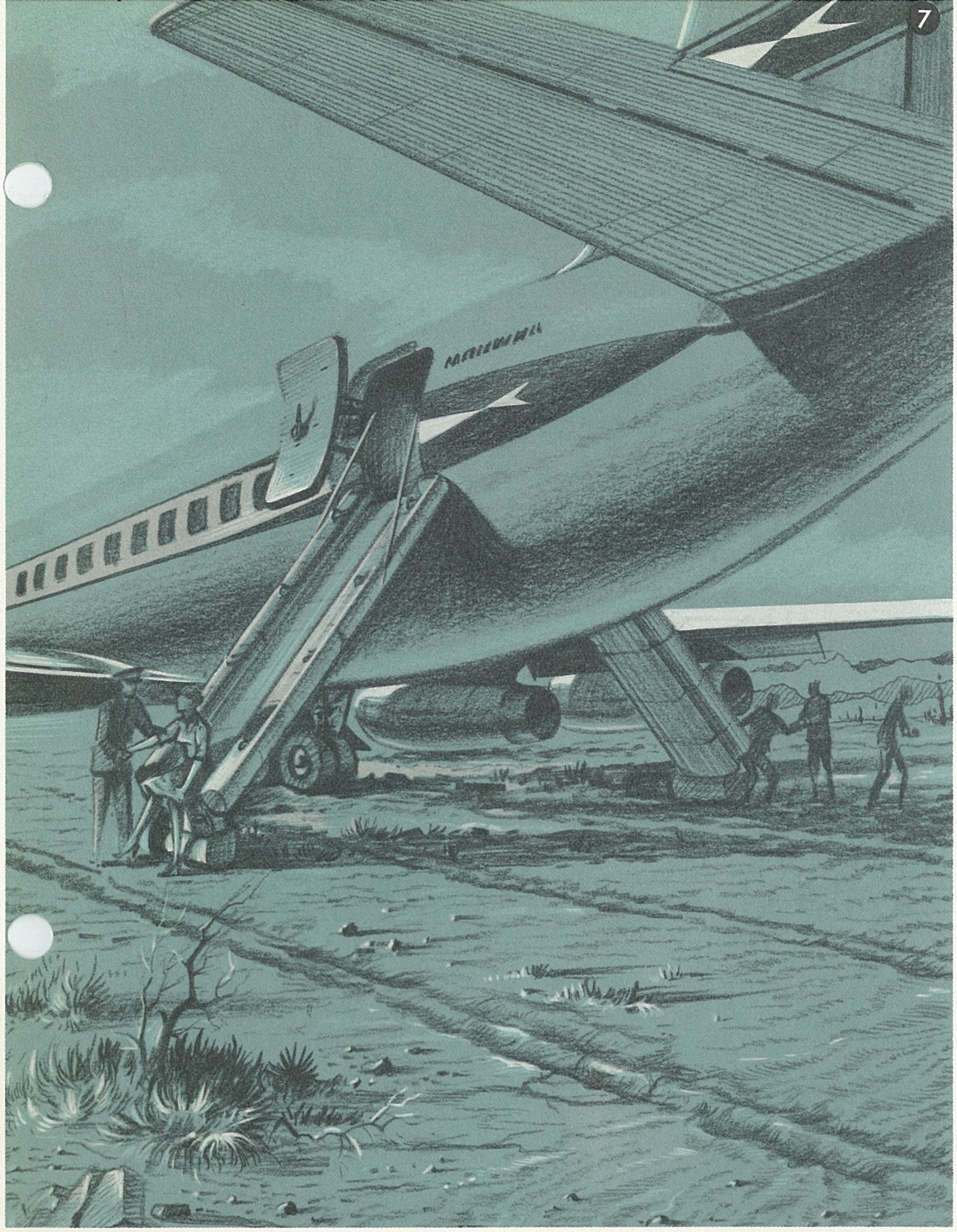
In case of puncture or inflation failure, the slide may still be used successfully as a noninflatable slide. This condition will require the assistance of two attendants on the ground to steady the bottom of the slide. The slide may also be used for airplane re-entry in either the inflated or deflated configuration by the use of handholds attached to the guide rails.

The slide has a useful life period of five years under normal climatic and stowage conditions. It is capable of withstanding heat of 300°F for 90 seconds and still retain a satisfactory sliding surface. The slide and its inflation system are designed to operate effectively throughout a temperature range of —20°F (—6.7°C) to 140°F (60.6°C).

The slide for the forward main entrance door inflates to a length of 114 to 123 inches. The slide for the rear main entrance door normally inflates to a length of 134 to 144 inches, but may be extended to 174 to 184 inches in case of an elevated aft fuselage due to a nose down condition caused, for instance, by a collapsed nose gear.







1 Inflatable emergency escape slide compartment is adjacent to main entrance door.

2 When inflatable slide compartment latch is actuated, slide drops across threshold.

3 Restraining straps are hooked to correspondingly colored fittings on door frame.

4 Slide bundle is rolled out doorway before being inflated; restraining straps support it.

5 Slide is inflated by pulling exposed "T" handle at the top of stowage compartment.

6 Slide rapidly and automatically inflates to pressure of 2 psi in only 5 to 8 seconds.

7 Inflatable slide is designed to handle 55 persons in FAA requirement of 90 seconds.

6 40

Jet-Age Glossary

AILERONS Control surfaces on wing trailing edge to aid in lateral control (banking).

ANTI-SHOCK BODIES Streamlined shapes on the wing (990 only) that delay the formation of shockwaves, thereby cutting drag at high airspeeds.

ATC (Air Traffic Control) A division of the FAA that maintains airway control and navigational aids for airplane traffic on established airways.

BUFFETING Shuddering of the airplane in flight caused by aerodynamic disturbances. Extending spoilers and landing gear at high speeds can cause buffeting.

CAB (Civil Aeronautics Board) Government regulatory and investigative body that prescribes civil air regulations, certificates airlines, and establishes routes, rates, and fares.

CEILING The height of a cloud base above the ground. Also the maximum serviceable operating altitude of an airplane.

CLEAR AIR TURBULENCE Turbulence without clouds, often along the edge of a jet stream.

COMPRESSOR That portion of a jet engine that compresses air and drives it into the combustion chamber.

CONTROL TOWER Elevated glass-walled enclosure at edge of the runway, occupied by FAA personnel who control aircraft approaching, landing, and taking off.

EMPENNAGE The tail section of an airplane.

FAA (Federal Aviation Agency) Government agency that serves the public in the fields of aviation safety, airways, airports, development, and information.

FLAPS Portions of the trailing and/or leading edges of a wing that may be extended to offer additional lift for takeoff and landing.

FLIGHT PLAN The anticipated routes, altitudes, times between points, and conditions to be encountered on a proposed flight, and the resultant information planned to best advantage.

FUSELAGE The main body of an airplane.

GROSS WEIGHT The total weight of an airplane including fuel, passengers, cargo, and equipment.

GROUND SPEED The actual speed of an airplane over the earth's surface.

HEADWIND Wind blowing against an airplane's line of flight, thereby slowing its ground speed.

HOLDING A delaying flight pattern in the vicinity of an airport, waiting to land.

ILS (Instrument Landing System) A radio system to guide aircraft to a landing under conditions of poor visibility.

INSTRUMENT FLIGHT Flying an aircraft by reference to instruments only. Referred to as IFR (Instrument Flight Rules).

JET STREAM High altitude air currents of great velocity, often reaching speeds of hundreds of miles per hour. Can assist aircraft speed, depending on direction of jet stream.

KNOTS Nautical miles per hour. Used only as a unit of speed and not as a measure of distance.

MACH NUMBER Speed in relation to the speed of sound. Mach 1 is 760 miles per hour at sea level, less miles per hour at higher altitudes.

MARKER An electronic navigational check point, such as marker beacon, that transmits signals from which an aircraft can determine when it is directly over a certain point on the ground.

OVERWEATHER In the smooth upper air above clouds and associated turbulence (sometimes referred to as "on top").

PATTERN Predetermined flight circuit adjacent to an airport, preparatory to landing.

PRESSURIZATION Maintaining the occupied compartments of the airplane at a comfortable pressure level during high altitude flight. The Convair 880 and 990 maintain an 8000-foot cabin altitude up to an airplane altitude of 41,000 feet.

RADIO BEAM A linear radio signal that can be received by the pilot and followed like a path in the sky.

SHOCK WAVES A wave, sometimes visible, that forms when air flows over a body at the speed of sound. On near-sonic jet airliners, shock waves can sometimes be seen on the upper surface of the wing.

SLATS High-lift devices such as long narrow vanes that can be extended forward from the leading edge of the wing.

SOUND SUPPRESSORS An extension on the tail cone of a jet engine (not required on the 990) to suppress the sound of the engines.

SPEEDBRAKES Appendages on the upper surface of the wing that may be extended into the airstream to increase drag of the airplane and slow it down. The landing gear may also be extended as a speedbrake.

SPOILERS Appendages on upper surface of wing that can be extended to increase drag and also to aid in lateral control.

STACKING Maintaining an altitude separation (usually 1000 feet) between aircraft in the vicinity of an airport, waiting to land.

STATIC DISCHARGERS Devices attached to wing and stabilizer tips and trailing edges to discharge static electricity in flight.

SWEEPBACK A wing or horizontal tail surface wherein the leading edges slope backward from the longitudinal centerline.

TAILWIND Wind blowing in the direction of the airplane line of flight, thereby increasing its ground speed.

THRUST The force of the mass of gases being discharged by the engine, producing forward motion of the airplane.

THRUST REVERSER A device on aft portion of jet engine that may be engaged to brake the aircraft and shorten the landing roll by reversing the direction of thrust.

TURBINE WHEEL A windmill-like wheel of curved blades that drives the compressor in a jet engine. It is located aft of the combustion chamber and is rotated by the discharge of expanding gases.

TURBULENCE Rough currents of air caused by rising warm air and descending cold air, or air moving over such ground obstacles as mountains and cities. Also caused by crossing the shear line of a jet stream.

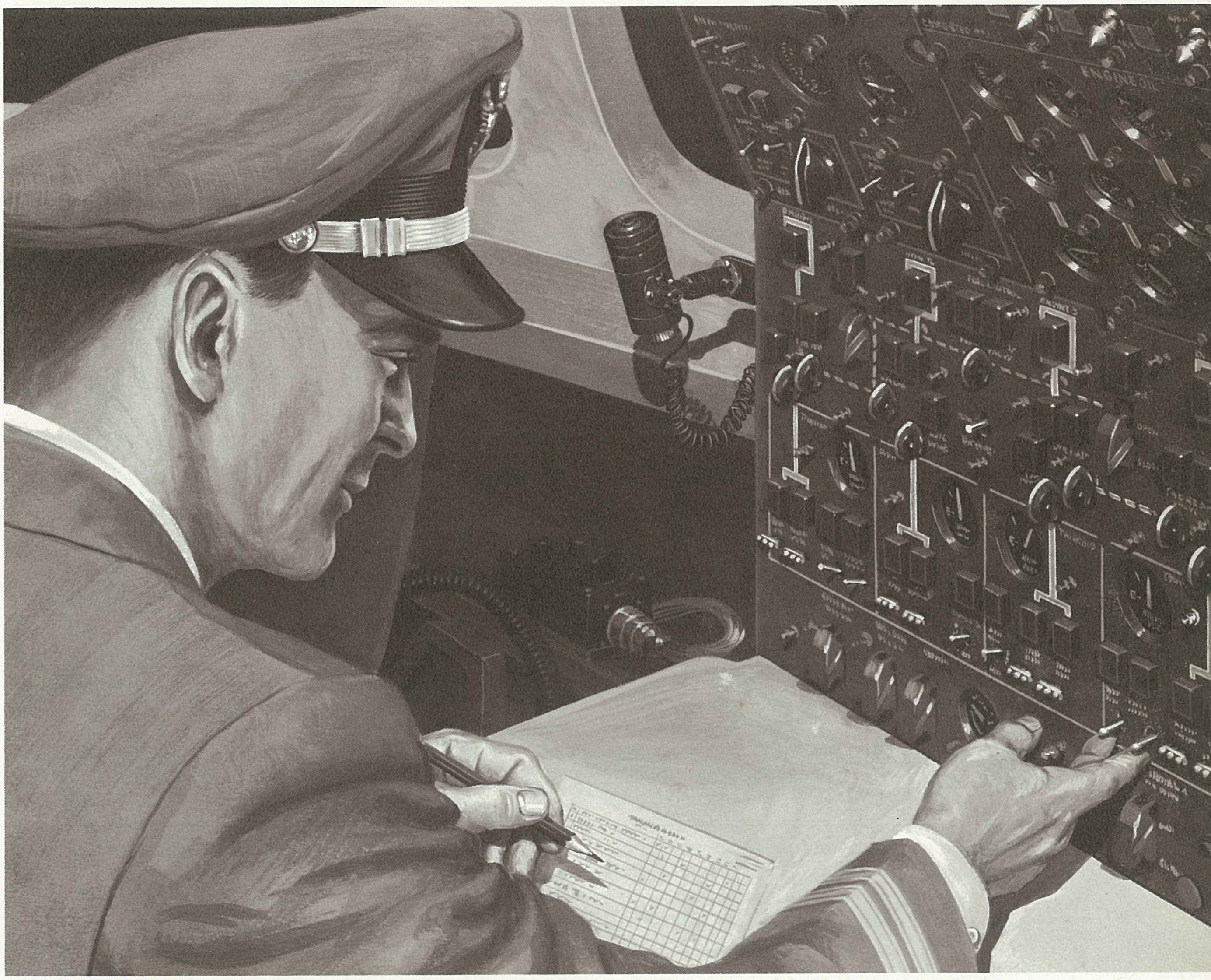
VISIBILITY The horizontal distance from which prominent objects are distinguishable. On a clear day, free of haze, precipitation, and similar atmospheric conditions, visibility may be nearly 100 miles.

VOR (Very high frequency Omni-Range) Radio navigational system, which transmits radial beams that can be followed by instruments or by automatic pilot.

VORTEX GENERATORS Small airfoil sections, perpendicular to a surface, which increase the effectiveness of control surfaces throughout various speed ranges.

VOLUME XIII NUMBER 9 JANUARY 1962

Convair Traveler



In this Issue: The Flight Engineer

OUR COVER

The flight engineer, fair weather or foul, is always "on instruments." While the pilots fly the airplane, his task is operation of the all-important systems that keep it flying. The artist — Bob Kemp.

Convair Traveler

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IN THIS ISSUE

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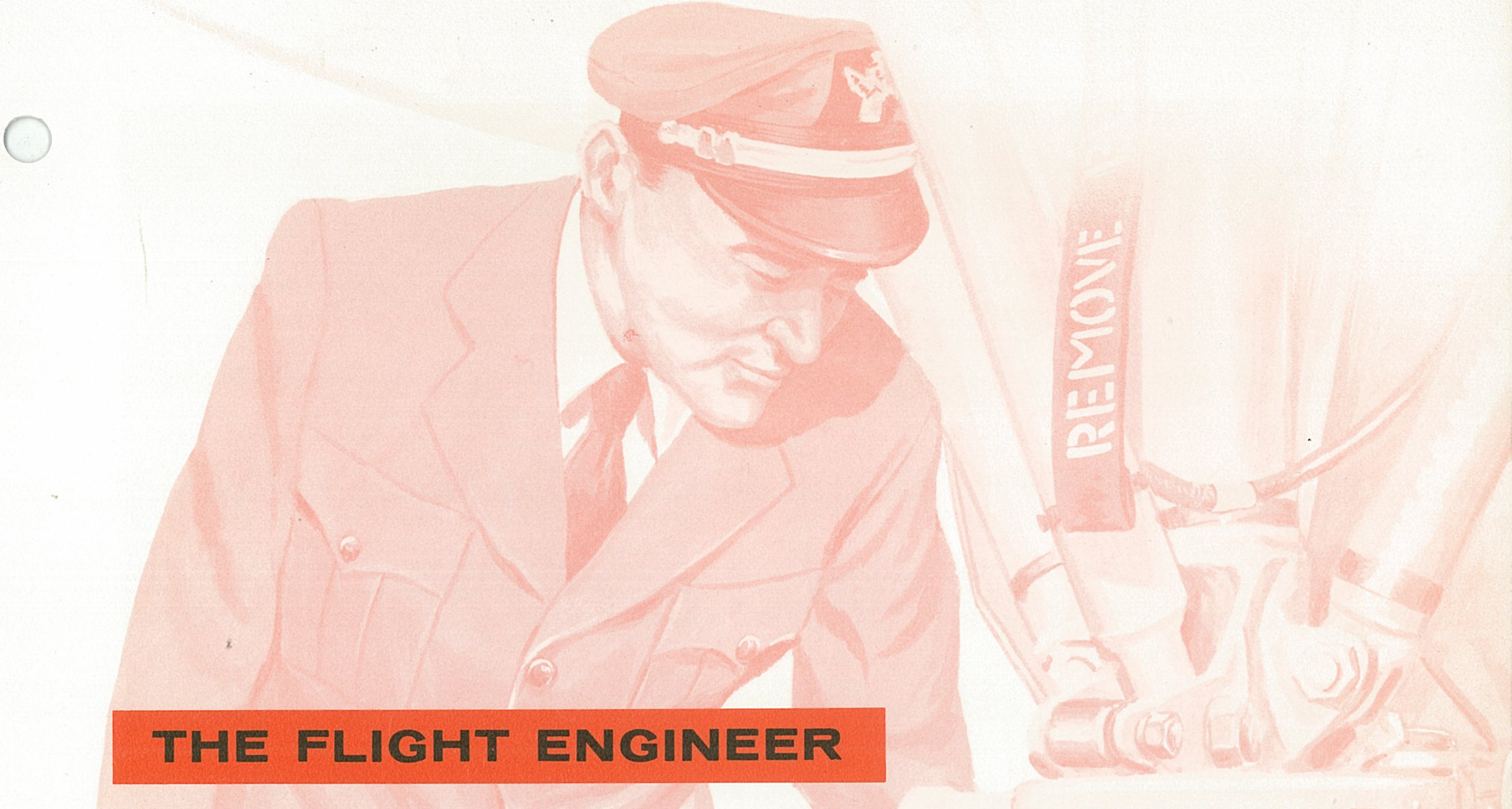
GENERAL DYNAMICS|CONVAIR



THE FLIGHT ENGINEER

Visitors to the flight deck of jet transports have on occasion remarked that any conversation with the crew is likely to be with the pilots. The flight engineer often appears too preoccupied for small talk. He seems to be incessantly figuring, writing things down, leafing through dog-eared notebooks in search of something, turning dials, or flipping switches.

To some extent, this picture of apparent pilot leisure and flight engineer industry is deceptive. In the specialization of tasks made necessary by the complexity of big airliners, the flight engineer has assumed some chores that require more visible activity. At cruise, on an uneventful domestic flight where nothing goes wrong, the engineer's paperwork is mostly routine logging. His main job, like that of the pilots, is monitoring — maintaining a constant watchfulness over a considerable array of instruments, switches, and flashing lights.

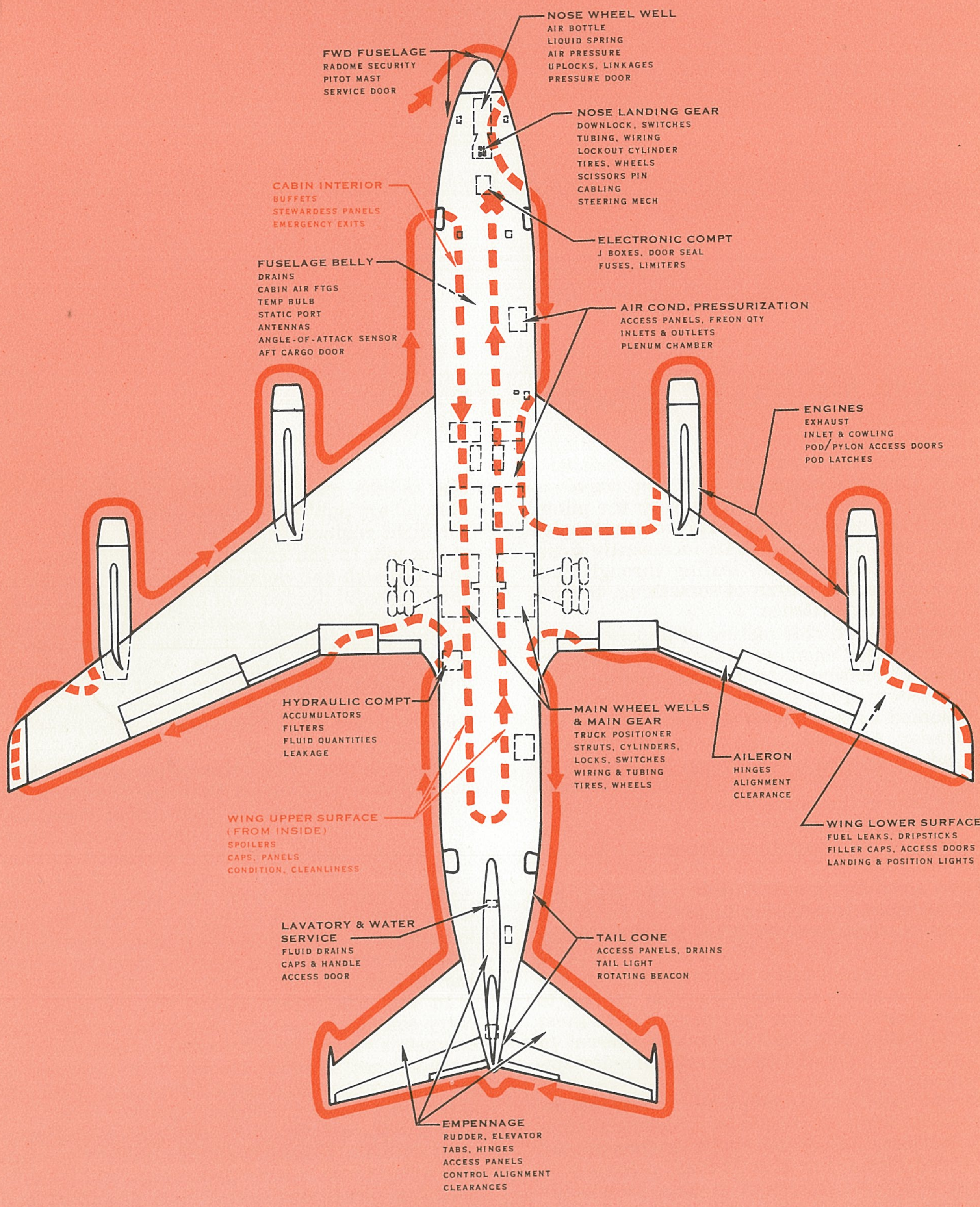
When anything is out of order, the flight engineer becomes, in addition to part of the flying team, an ex officio member of the keep-'em-flying team — the ground crew. There are two aspects of his duties as in-flight representative of the maintenance gang. He must do what he can to keep the aircraft systems operating; and he must note and record any signs of trouble, present or in prospect, to guide the ground crew in maintaining the airplane.

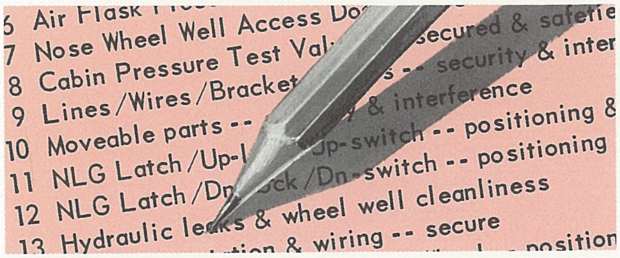
No one publication completely covers all aspects of the flight engineer's job. For initial (factory) training of airline flight engineers and pilots, the Flight Training Manual prepared by Convair's flight department is used as a classroom text. Thereafter, the airline operator's own manual, the FAA-Approved Flight Manual, and the 18-inch shelf of the Convair Maintenance Manual are published reference works of value to the flight engineer in the day-to-day performance of his job. In the end, however, achievement of the thorough and detailed knowledge needed for the successful discharge of his professional duties may come from many sources: basic engineering theory, manufacturers' manuals, service reports, even brochures and catalogs. And, most importantly, along with knowledge must go a fingertip know-how in managing the aircraft systems from the flight deck — a know-how acquired only by training and experience.

One difficulty with information gleaned from maintenance manuals is that the information is often in reverse from an operational viewpoint; certain phenomena or malfunctions may cause *this* or *that* effect, with *such-and-such* warning lights and operational changes. The flight engineer is confronted with the effect and must work back to probable cause, so that he may know what he can do about a malfunction while still airborne and what must be done to correct the trouble.

In this and future issues, the Traveler will carry some data specifically slanted to the flight engineer's viewpoint. This article is introductory, intended not so much for the flight engineer as for the layman who may have some curiosity about just what the flight engineer does for a living. Future articles will presuppose acquaintance with the Convair 880/990 aircraft systems and will contain specific data on in-flight trouble-shooting, identifying sources of malfunction, and how best to report them to the ground crew.

WALKAROUND INSPECTION





WALKAROUND AND PREFLIGHT CHECK

Some time before the passengers have lined up at the gate to board the airplane, the cockpit crew will have checked in and gone to work. While the pilots concern themselves with weather, flight plan, and the takeoff weights and speeds, the flight engineer checks the weight and balance and goes over the entire airplane.

The pilot of a small private aircraft may take anywhere from a minute up for his walkaround, looking for leaks, control binding, loose tank caps, and checking the general look of things. The walkaround inspection time for a Convair 880 or 990 begins at about 20 minutes minimum, for the briefest en route stop, and may take an hour or more. There is not only a lot more to look at, there is also a heavy burden of responsibility. This airplane, weighing 70 to 120 tons, is going to fly nine to ten miles a minute, six or seven miles high, carrying a cargo of human lives. The walkaround is the last opportunity to catch up with any oversights or to spot obscure symptoms of incipient trouble.

The original FAA-approved walkaround check list contained more than 150 items. By now, most operator's lists are longer . . . and they usually note that only the major items are spotlighted. No matter how well the flight engineer has memorized the list, he must carry it with him on his tour.

Usually, he begins at the nose, works back on the right side of the wing, out to the wingtip and back, around the empennage and up to the left wing, around it and forward to the nose. What does he look for? The answer can only be that he looks at everything in sight, and very carefully at most of it. Some of his looking inspection depends on what psychologists might describe as "Gestalt" recognition — things should look right. He must have in mind the general appearance of a landing gear, say, well enough to sense anything out of the ordinary even before he identifies what it is.

Many things he examines very specifically. He will have with him a record of maintenance accomplished at this stop and will doublecheck all that he can. At the landing gears, he will check each door and gear uplock and downlock, switch actuation, brake lockout; also emergency brake and brake modulator pressures, nose gear liquid spring pressure (on the 880/880M), main gear truck positioner, emergency extend linkages. He may remove downlock pins as he goes.

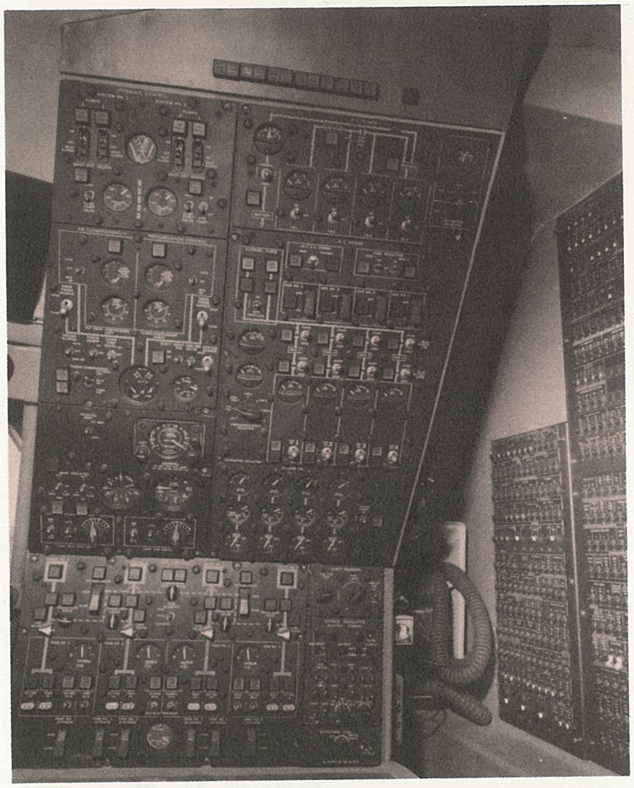
On the fuselage, he examines belly antennas, pitot and static ports, freon quantities, air conditioning inlets and outlets, vents and drains. He looks into cargo and electrical compartments. In the hydraulic compartment he checks reservoir levels, accumulator precharges, lines, valves and filters.

Everywhere, on the fuselage, wing, and tail, he is automatically eyeing each access door or panel for loose fasteners, bad seals, or an ill fit. Everywhere, he looks for signs of leakage from fluid-carrying lines and from fittings. Fuel and oil caps must be secure, water and lavatory drains dry. He keeps a constant vigil for loose objects—tools and the like — in engine inlets, wheel well doors, compartment floors, air vents and intakes, and on upper wing surfaces. At engine inlets, he checks ice detector and temperature probes for security and cleanness; at the exhaust, he looks for cracks or other signs of heat damage, and checks apparent condition of temperature and pressure sensors. He looks for misalignment of engine cowlings, doors and panels, and particularly of control surfaces; a rubbing tab, or some object caught in a hinge, could mean major trouble in the air.

All this must be deliberate, methodical, with conscious concentration, and with awareness that something new and heretofore unknown may show up anytime, anywhere. It must be done in definite order, so that if the inspection is interrupted, it will be resumed with no omissions. The walkaround will probably be most exhaustive when the flight crew first comes on duty; it will be repeated before every flight, and, should the departure be delayed any length of time, repeated again before takeoff.

The exterior walkaround is the major part of the flight engineer's preflight check. The rest is inside the cabin and cockpit. Some cabin inspection duties may be shared with the stewardesses, depending on the operator; usually, the flight engineer is charged with responsibility for emergency equipment . . . oxygen, fire fighting, and escape . . . for stewardess panel operation, and for the water system.

In the flight compartment, after checking emergency equipment and oxygen, the flight engineer will check over the circuit breakers to the right of his station . . . 350 to 400 of them on three panels. Below his desk is a panel of current limiters to be checked for blown units and spares. Then he will go over his main panel, system by system . . . checking switches, press-to-test warning lamps, indicators, fuel line valves, and pumps. The DC and 26-volt AC electrical power supply systems can be checked with ground power; the AC system will have to await engine start. He at least shares responsibility with the pilots for the overhead panels, and may check much of the controls and panels at the pilots' stations, depending on company practice or the preferences of the crew.



System control panels face flight engineer. Below shelf desk are main ac buses and limiters. DC buses are below CB panels on right.

FLIGHT DUTIES

The flight engineer's formal prestart check list will have 30 to 40 items. After engine start, he will switch over from electrical and air conditioning ground carts to ship operation; he will parallel the generators, and set the fuel and cabin air systems for takeoff.

From then on, the flight engineer will never have his panel out of his range of vision for more than a few seconds at a time. If he has to leave his station, someone else must watch it. He may help monitor the center panel engine instruments, particularly during takeoff roll and initial climb, and log the readings from time to time. But on his panel will appear the first warnings of anything gone wrong in the all-important pressurization, fuel, hydraulic, or electrical systems.

When such a warning appears, the flight engineer must alter the control panel configuration to normalize the situation. If the situation calls for further action, the flight engineer must be prepared to make whatever actual system adjustments may be necessary or possible in the air.

The routine chores are enough to keep him intermittently occupied. During climb after takeoff, he will be resetting cabin temperature and altitude controls, and will be concerned with fuel management. Fuel quantities should be approximately equal in all tanks. Since the inboard tanks hold more, he may have to crossfeed. If there are center section tanks in the fuselage, these will be emptied in proper sequence.

Keeping track of fuel consumption is more of a task than it was with reciprocating engine aircraft; relative fuel weight is higher and burnoff much faster. Temperature and altitude make a great deal of difference in thrust and jet engine efficiency. Where the piston engine transport flight engineer may log fuel every hour, the jet flight engineer will probably log it every 15 minutes. In a long overwater flight, the flight engineer may find himself pretty busy. Every change in flight plan demands a whole new set of estimates of time and range remaining, time of arrival, fuel aboard at destination, and margin for holding or reaching alternate airports.

When a warning light comes on or an indicator begins to go awry, the flight engineer's duties complicate rapidly. His response must be prompt and sure. He must know what is happening and what the effect will be on the flight; what he can do to meet the situation; and what must be done on the ground to remedy the trouble. He must know the effects of breaker resets or limiter replacement, and what the limits are — whether a unit can be held inoperative for emergency use, or what damage will ensue if an evidently malfunctioning unit is kept running.

Besides the indicators on his panel and the switches he can reach, the whole airplane is his to look after. If radio or instrument trouble develops, he must log it intelligently. Should a landing gear misbehave, or a passenger door stick, he will be called on to do what he can. He must be the airplane's engineer in all fields and its jack-of-all-trades as well.

During letdown and approach, he will be busy again with cabin air and fuel management. Weight distribution is important during landing, and fuel will be used selectively from some tanks or even transferred. Back on the ground, he shuts down his systems one by one, sets up for the ground power and air conditioning carts, and finishes off paperwork. The men who refuel and perform line maintenance will start in with his reports. There are, literally, thousands of items that can malfunction, if one counts only the switches, motors, valves, and actuators in a jet airliner.

Most flight engineers, it will be found, are pilots themselves with one or another kind of license, and in some airlines they are qualified to pilot the airplane they fly in. But the FAA does not require pilots for the job. What the flight engineer has to know is his airplane, inside and out, and how it operates on the ground and in the air. There is a minimum amount of knowledge he must have, but there are no maximums. Every bit of information or know-how helps in system management. The more he knows, and the better he is able to use his knowledge, the safer will be the passengers and the more efficient and profitable the airline operation.

SAFETY AROUND JET ENGINES

CERTAIN PRECAUTIONS ARE NECESSARY to safeguard the health and to ensure the safety of personnel engaged in maintenance and servicing in the area of jet engine operations. These precautions involve safety measures with respect to jet engine noise, inlet suction, and exhaust heat and blast.

Jet engines, developing more power and expending more energy than conventional aircraft engines, also produce more noise. Unless personnel in proximity to operating jet engines are protected, they can receive permanent injury from the high noise levels.

Two basic types of noise are produced by turbojet engines. One is the wide-band noise of the jet exhaust which predominates during high power settings at engine trim and takeoff; the other is the narrow-band compressor whine (and the fan whine peculiar to the "990" aft fan engines), which is most apparent at lower power settings associated with ground handling. Enclosed ramp areas, gate houses, and terminal buildings usually furnish waiting passengers sufficient protection from turbine or fan whine.

The deafening sound of a full-powered jet engine requires special attention if personnel are to remain in the area for any length of time. Ear plugs, ear muffs, and helmets offer varying degrees of sound attenuation and hearing protection.

Sound is measured in decibels (db) — units of sound pressure. Powerful jet engines are capable of producing sound levels of the order of 145 db — and more. Personnel are rarely required to be exposed to such levels, however, since these levels exist only at high power operation and in limited areas. If protective devices were not used, personnel who are subjected to noise of this intensity for even short periods of time would suffer damage to their hearing. Even an exposure to SP levels of 110 to 130 db could cause a *temporary* hearing loss if ear plugs or muffs were not used.

Another important factor to be considered in determining hearing damage risks for personnel who are subjected to jet noise is the duration of exposure. In the higher noise levels, prolonged exposure to a noise of comparatively low intensity has the same effect as a high intensity noise for a shorter period of time. As an example, eight hours of exposure to 85 db is equivalent to one minute exposure to 111 db; one minute exposure to 111 db is equivalent to six seconds exposure to 122 db.

The use of either properly fitted ear plugs or ear muffs will reduce the effective sound pressure level by approximately 15 to 25 db. Wearing a helmet will lower the sound level a comparable amount, and will also reduce sound transmission caused by bone conduction — a condition that is not usually critical with commercial jet aircraft. Diligent use of one or the other of these sound reduction devices by personnel will usually provide adequate noise protection at all normal work stations.

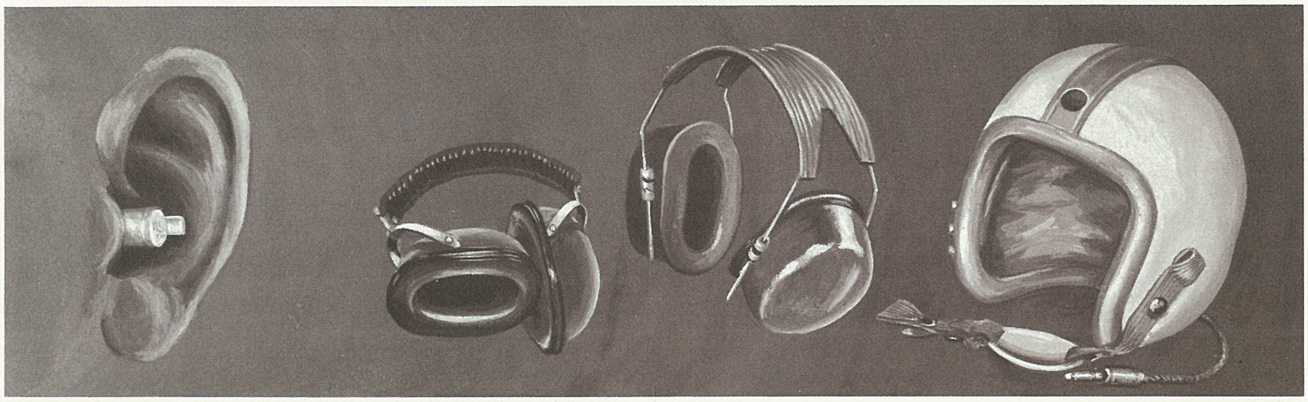
The following conservative rules are regarded as necessary safety measures for personnel who are required to frequent areas in proximity to operating jet aircraft engines. The figures are approximations.

1. Within 100 feet of an operating jet engine, all personnel should be required to wear properly fitted ear plugs, ear muffs, or a helmet.

2. At a distance of 100 to 200 feet of an operating jet engine, ear plugs or ear muffs should be worn by all personnel, if the engine is running above idle power.

3. The doors and windows of buildings and enclosures near ramps and parking areas should be closed when jet aircraft are running their engines. Ear plugs need not be worn by personnel remaining indoors.

More detailed rules should be established for particular operations based upon a study of the noise characteristics of the engine (frequency distribution and direction distribution of noise energy about the airplane), the typical daily engine operating schedules, and the anticipated work schedules of exposed personnel.



Engine run-ups at full power are required to be conducted on the ground after the performance of certain maintenance operations. In a successful effort to reduce jet engine noise at its source, and permit these high-power engine run-ups without the need of isolated test cells, portable sound silencers have been developed that may be positioned at an engine tail pipe, regardless of the location of the aircraft. These sound silencers effect a reduction of sound pressure level in the immediate work area to expedite preparation of jet aircraft. The sound attenuation also has a tendency to greatly improve airport and community relations.

If properly positioned at the engine tail pipe, portable sound silencers are capable of reducing the sound pressure level of a full-powered engine run-up more than 20 db. This degree of sound attenuation represents a substantial slice off the top of the high intensity noise peak and, when used in conjunction with personal safety devices, results in greater safety and comfort to personnel working in the immediate engine test area.

The suction generated at the inlet of an operating jet engine is perhaps the greatest hazard associated with jet aircraft. Danger is increased because there is no visible indication of the inrushing air. Personnel should always give the engine inlet ducts a wide berth when the engines are running. The suction danger area is within a 25-foot radius of the engine inlet duct.

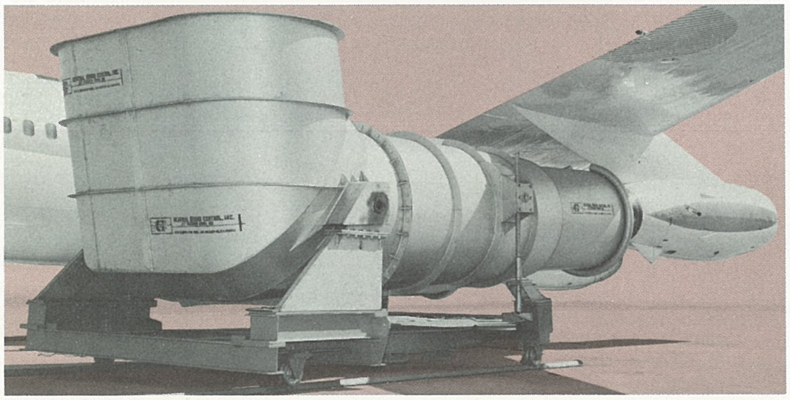
Only those persons whose presence is absolutely necessary to the operation of the engines should remain in the vicinity of the aircraft when the engines are started. Most operators rope off the danger areas of their jets before starting the engines, if the aircraft is to remain on the ground for any length of time.

A safe rule to follow, when working around operating jets, is to always keep at a distance of several feet outboard from the wing tip, and walk — never run — parallel to the fuselage. By the same token, keep at a distance of several feet forward of the nose tip and walk parallel to the wing.

Supporting equipment should also be kept at a safe distance from engine intakes, because dirt, debris, and various articles could be swept from the vehicle into the engine.

Small objects sucked into the engine constitute a threat to the safety of the aircraft. Even soft articles such as caps and rags can do considerable damage, if ingested. The ramps and working areas in the proximity of operating jet engines should be kept clean. No articles should be left in front of the engine, nor placed on the inlet ducts — even for a moment.

Blast and heat from jet engine exhausts can also be dangerous to personnel, but the nature of the blast usually renders the hazard almost negligible. Ordinarily, anyone approaching the tail pipe of an operating jet engine would receive

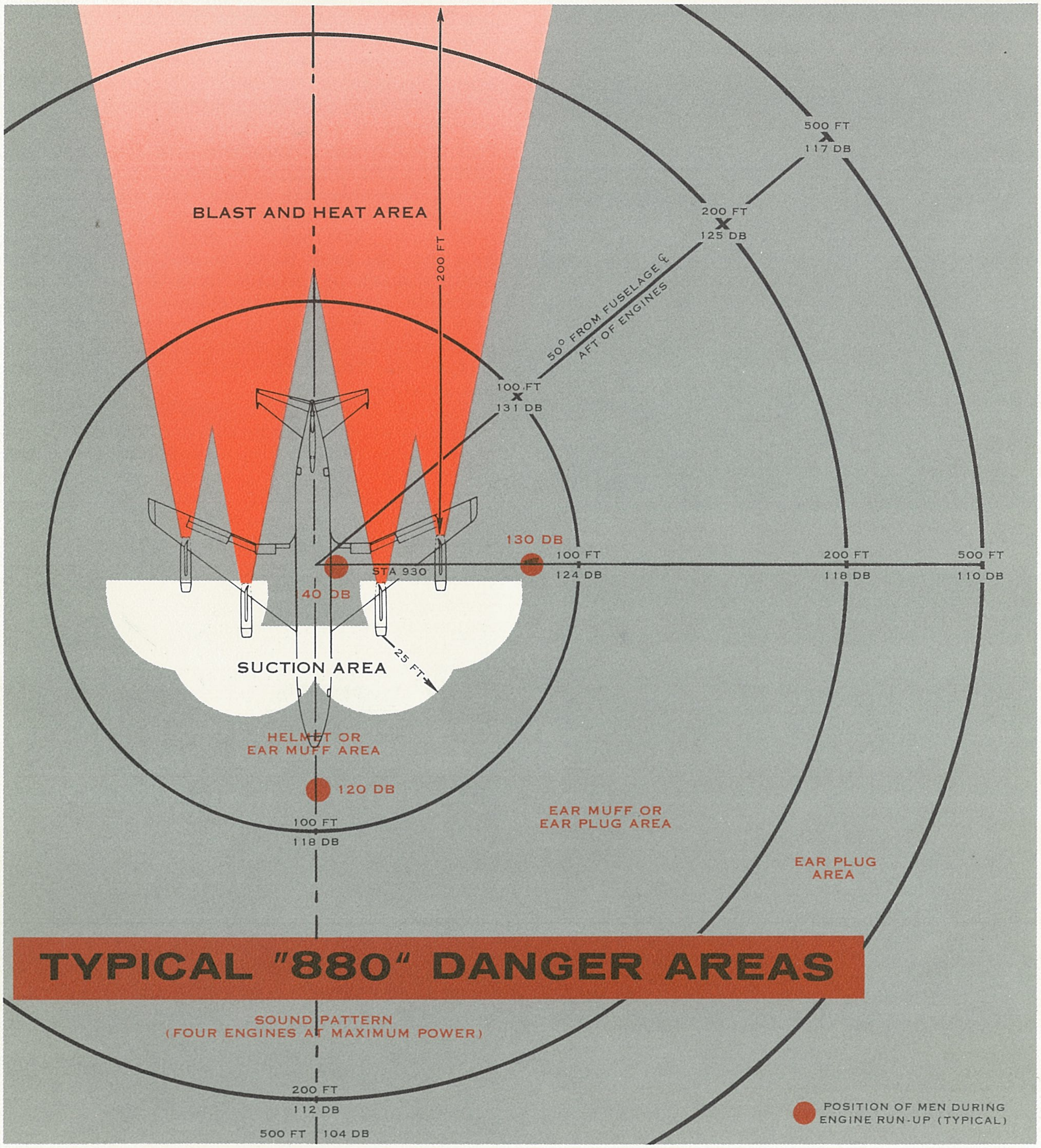


Portable sound silencer positioned at engine tailpipe during maximum engine run-up is capable of reducing the sound pressure level more than 20 db.

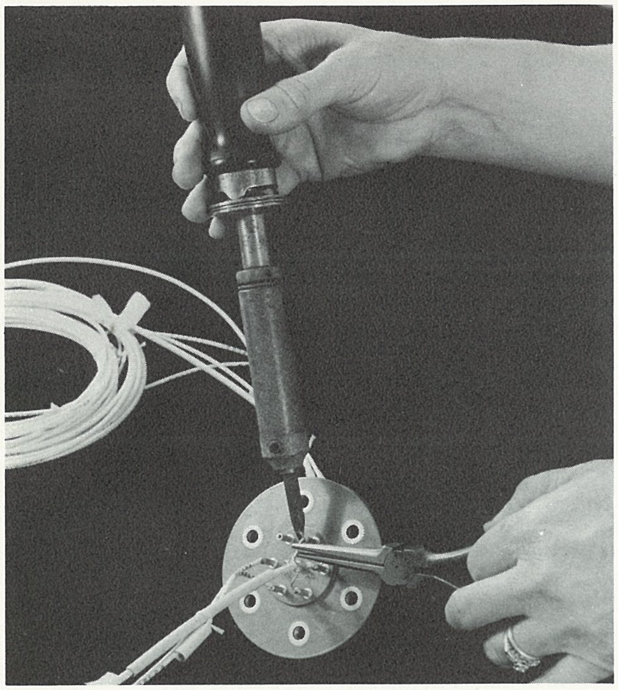
adequate warning of the danger, or be unable to advance close enough to suffer injury because of the tremendous force of the blast.

The temperature and velocity of the exhaust blast of a jet engine at takeoff power diminishes rapidly as the distance from the tail pipe is increased. Immediately aft of the "880" tail pipe, the temperature is approximately 1000°F. At 50 feet aft of the engine, the temperature drops approximately to 300°F, yet the exhaust velocity is nearly 900 knots. Between 50 and 75 feet behind the exhaust, temperatures approximating 200°F and velocities of 240 knots have been recorded. At a distance of 100 to 150 feet behind the engine, the temperature is approximately 150°F with gas velocities just under 60 knots.

Beyond 200 feet from the engines, personnel and equipment are comparatively safe.



HIGH-TEMPERATURE POTTING OF ELECTRICAL CONNECTORS

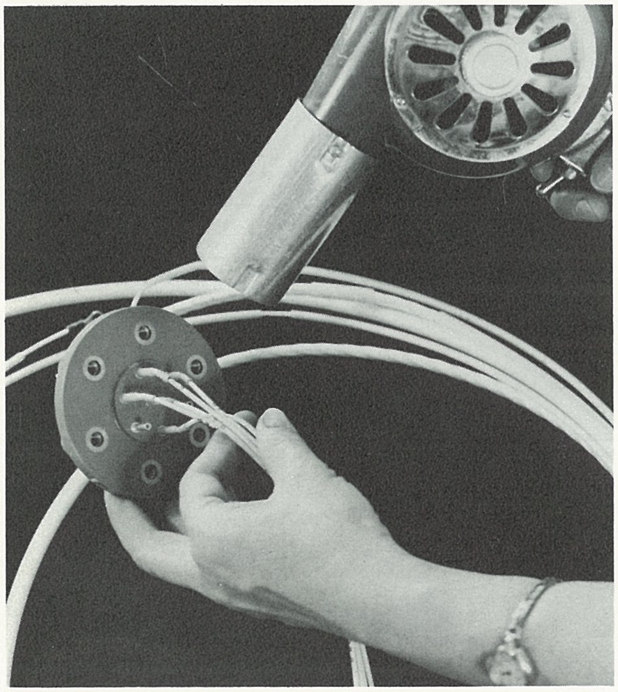


Wiring connections are soldered to tank feed-through.

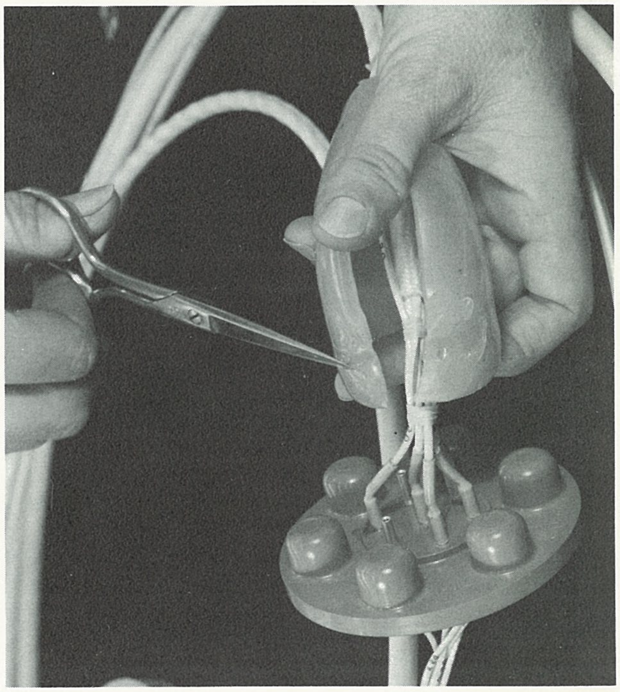
ELECTRICAL AND ELECTRONIC WIRING harnesses, fabricated for the "880" and "990" jet airliners, use literally miles of wire in their total construction requirements. Where harnesses must meet unusual environmental requirements, high temperature potting is used in their fabrication.

One of the special harnesses, which utilizes the advantages of potting, must pass into the wing fuel tanks where it connects with electrical controls and fuel sensing equipment. This particular wiring assembly has several environmental requirements that make the use of potting advantageous. The point of entry of the harness into the fuel tank must be fuel-tight; the connection must be capable of withstanding considerable temperature variations; it must be impervious to moisture to preclude corrosion; it must provide reliable electrical continuity and, at the same time, have a high degree of mechanical toughness.

Fuel-tighting of the harness at tank entry is made possible by soldering inner and outer halves of the cable assembly to a plastic feed-through fitting which, when the potting is complete, becomes an integral part of the cable assembly. It is bolted and sealed, on installation, to the opening in the fuel tank wall.



Heat gun is used to shrink sleeves over connections.



Potting mold is trimmed and slipped over connections.

It is important that vibration be damped to preclude breaking of the soldered connections, and that connections be protected against inadvertent bumping by maintenance personnel at the cable assembly feed-through fitting.

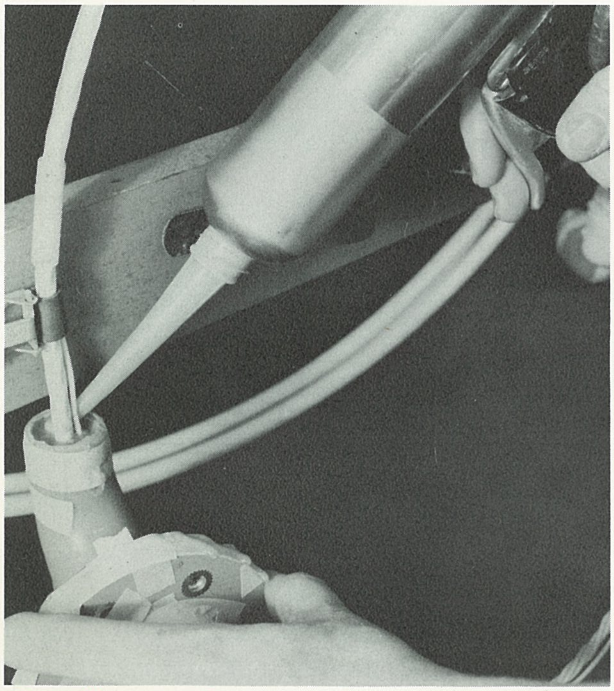
The advantages of potting in affording protection in these respects can be appreciated when it is realized that damage to the harness could involve draining of the fuel tanks to effect replacement.

The potting material used for this protection is a synthetic compound known as polyurethane. It is resistant to constant exposure of 300°F and to hydraulic fluids, aircraft lubricating oils, and jet fuel.

The material is procured in a pre-mixed, frozen condition and is stored at −30°F or colder at all times. As required, the material is removed from the refrigerator and "thawed" to an extruding viscosity. The thawing is accomplished by allowing the compound to stand at ambient (room) temperature for approximately one hour. This thawing can be speeded up somewhat by hand-kneading the material through the plastic container. Heating is not permitted for thawing.

By using the prescribed method for warming the material to room temperature, the compound develops its best viscosity for extruding and it attains the best "wetting" and consequent adhesion, to produce the best bonding.

When cured, the potting compound has a resiliency approximating that of medium-firm rubber. This effectively damps vibration, acts as a good bump absorber, and effectively seals against moisture.



Extruding procedure is completed with potting gun.

The feed-through harness is fabricated in two sections: the fuel-immersed section, and the tank external section. Attachment of these two sections is made at the connector plate by soldering. All soldered connections, wires, and wire insulation are carefully cleaned and dried. Then, preinstalled thermo-fit sleeving is slipped over the soldered joint at each wire. A heat gun is used to shrink the thermo-fit sleeving to a very tight bond over the soldered connection and wire insulation, thus providing a moisture-tight seal to the wire insulation.

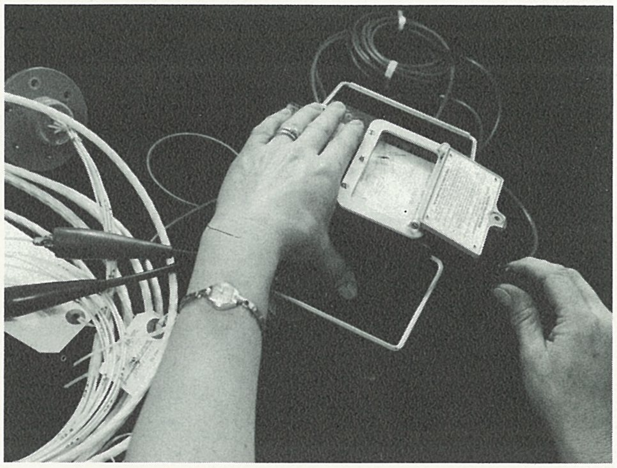
A light coat of potting primer is applied, and the potting molds are secured in place with tape. After the potting compound is carefully filled into the molds, it is allowed to stand for two hours. This permits any air bubbles, which may have formed, to work up and outward to the surface.

The potting is then inspected and the bubbles, if any, are broken to eliminate the air.

Final curing of the potting compound — from a viscous fluid to a pliable yet firm rubber — will occur at room temperature in not less than 48 hours. This is shortened in manufacturing by a carefully regulated oven heat of 175°F, which cures the compound in 2½ hours.

Each step in the foregoing fabrication process is carefully inspected. In addition, upon completion of a harness it is checked out to the requirements of an electrical overload on each individual wire so as to assure proper functioning in the event current surges are encountered in use.

The wires are again checked with a "megger" — wire for wire — across to each other wire in the harness. The purpose of "megging," or checking, the resistance *between* wires as well as *through* the wires, is to assure that a high degree of insulation has been attained in every part of the harness. Potted and checked with painstaking care at every step in their construction, these feed-through harnesses are then ready for installation.



Megger is used for making leak-check between wires.

NOSE WHEEL WELL ACCESS DOOR

A PRESSURE DOOR IN THE FORWARD ROOF of the nose landing gear wheel well of Convair jet airliners provides access to the general area forward of the flight compartment when the airplane is on the ground. This opening is used for servicing the battery, which is located on the right-hand side of the nose compartment, and for access to the area behind the instrument panels.

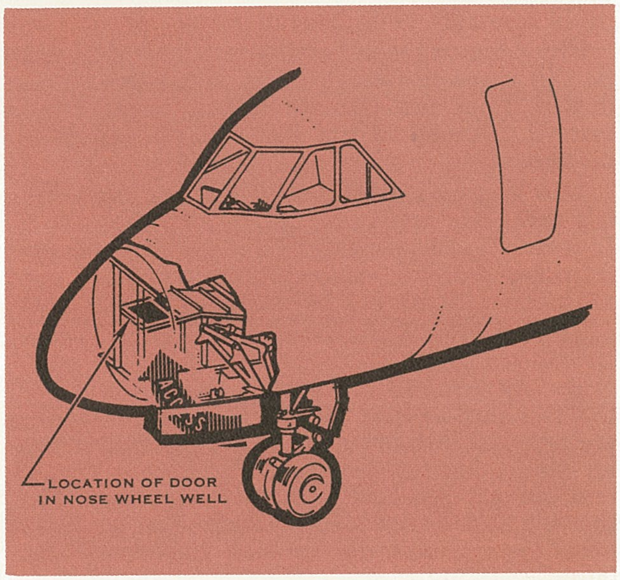
Improper installation of, or failure to install, the pressure door can seriously affect pressurization, necessitating a rejected flight with possible fuel dumping.

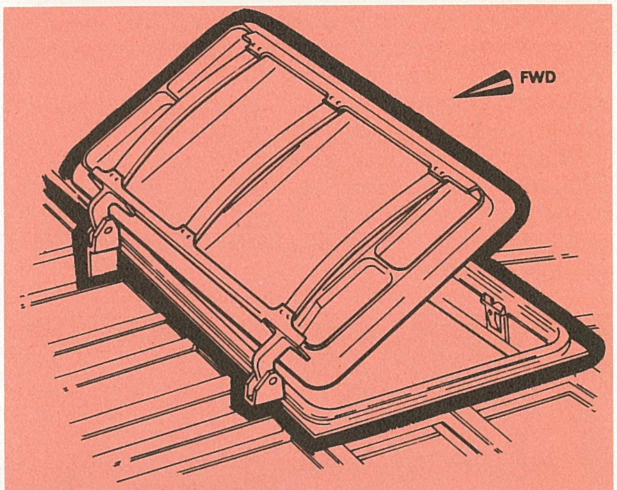
The door, hinged on the forward end, opens inward. It is secured by four quick-release pins; two pins on the aft end of the door secure and lock the latches, while the two on the forward side serve as hinges. The pins are removed and installed by depressing a button at the end of the pin. This action retracts a locking ball, which springs into the extended (locked) position when the button is released. Each pin is retained by a chain to preclude the possibility of loss of the pin.

A hold-open receptacle on the door mates with a strap on the bulkhead for holding the door open during maintenance operations.

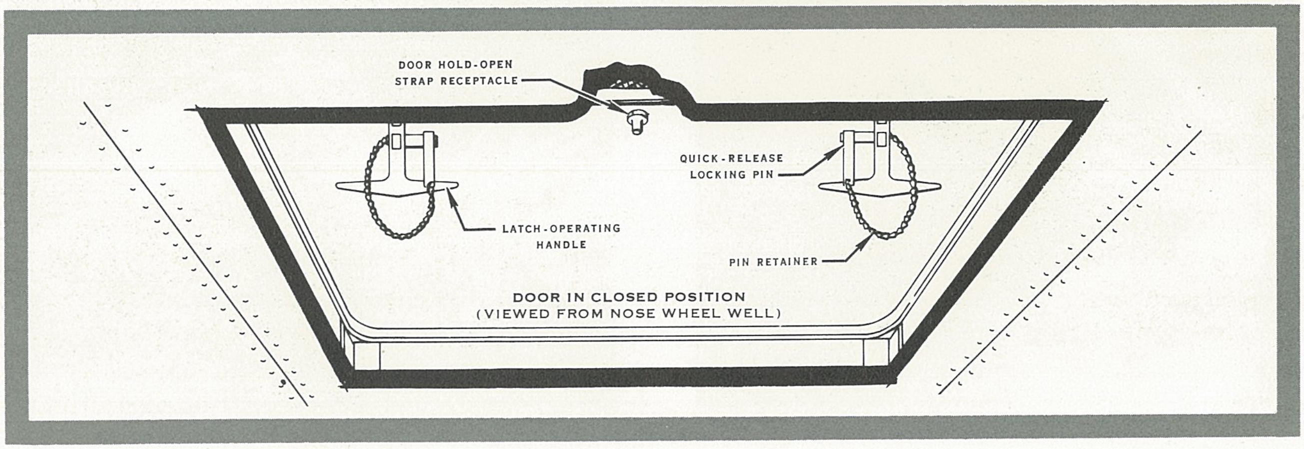
A self-energizing continuous-pressure seal is installed around the periphery of the door to insure a tight seal for retaining cabin pressure.

When installing the door it should be ascertained that the latches are fully engaged and that the seal is making contact around the door perimeter.





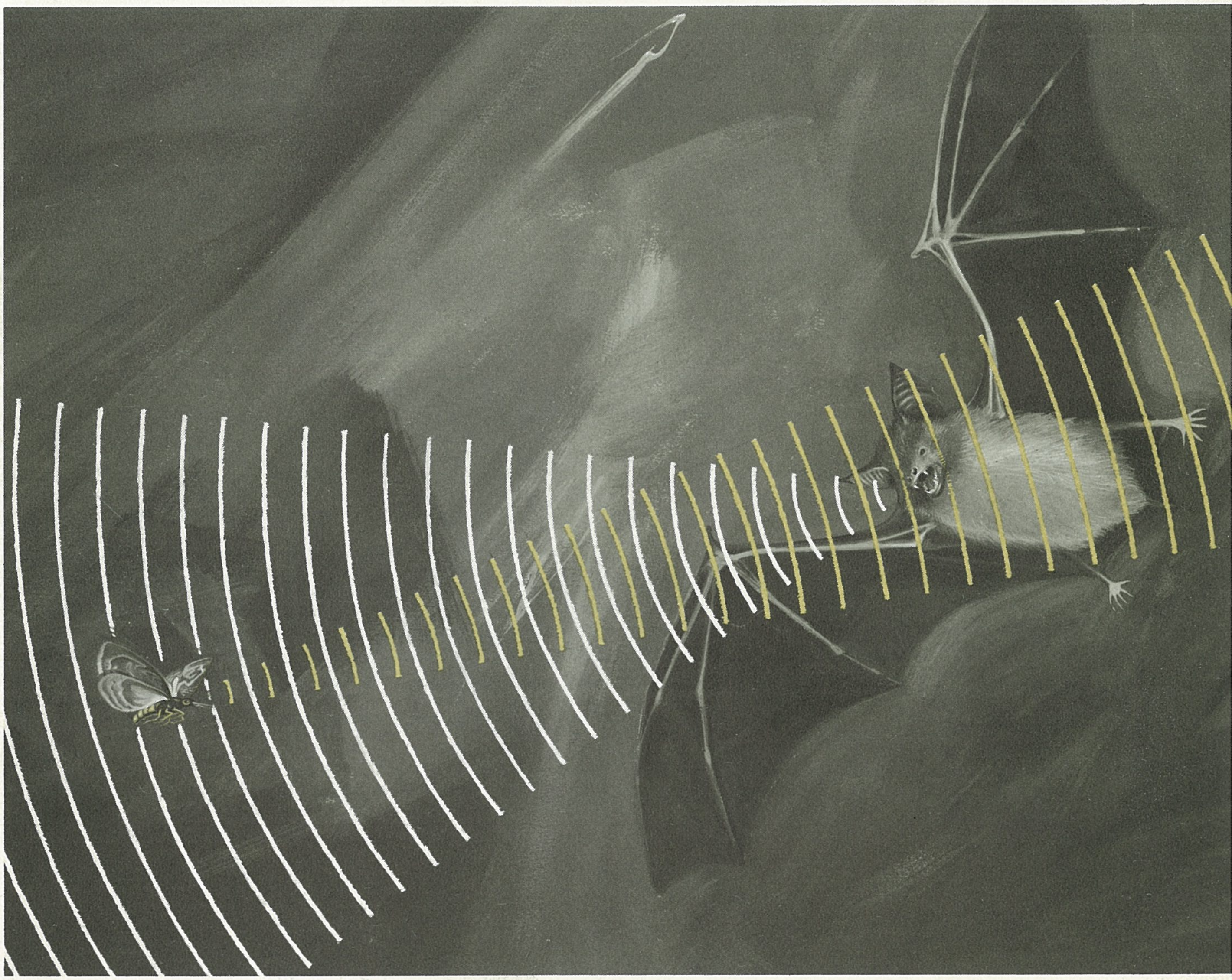
DOOR PARTIALLY OPEN
(VIEWED FROM INSIDE)



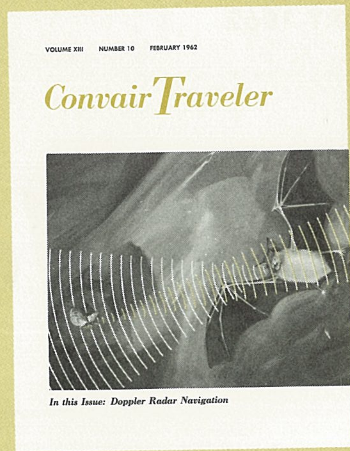
DOOR IN CLOSED POSITION
(VIEWED FROM NOSE WHEEL WELL)

VOLUME XIII NUMBER 10 FEBRUARY 1962

Convair Traveler



In this Issue: Doppler Radar Navigation



OUR COVER

Harvey Adams uses the bat to illustrate Doppler radar navigation. Like the Doppler system, the bat broadcasts signals that bounce back from the target — in this case, an insect. Its tiny, but mighty, brain evaluates the time delay between the outgoing pulse and the echo to determine speed and direction.

Convair Traveler

VOLUME XIII NUMBER 10 FEBRUARY 1962

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IN THIS ISSUE

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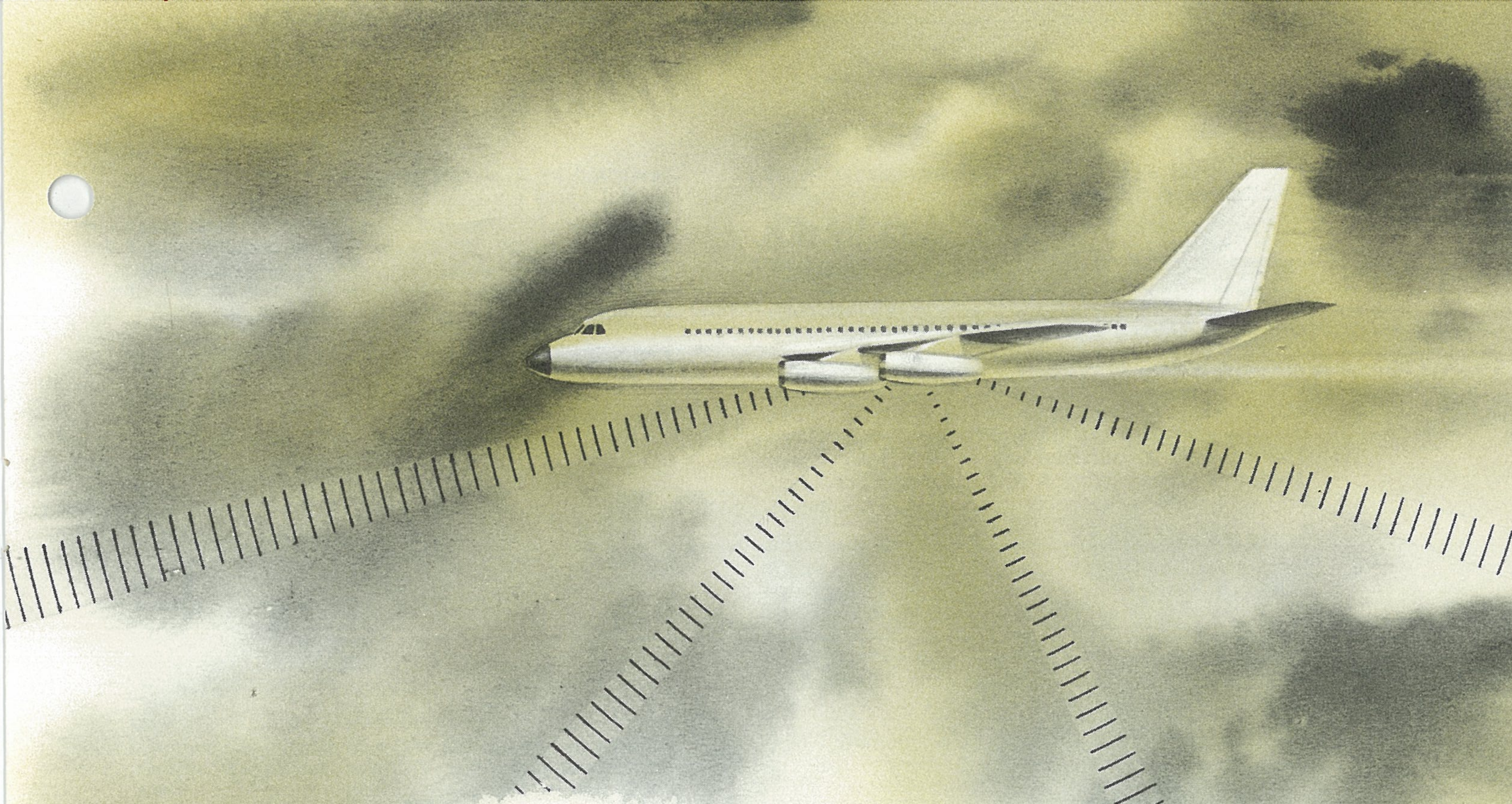


DOPPLER RADAR NAVIGATION . . .

SIXTY-ONE YEARS BEFORE the advent of powered flight, an Austrian named Christian Johann Doppler made a discovery that was destined to have a pronounced effect upon world travel a little more than a century later. He noticed that a sound, such as the whistle of a passing train, increased in pitch (frequency) while the source was approaching him, and decreased in pitch as it moved away. Further, he found this phenomenon was proportional to the velocity of the source, and relative to his position. This frequency shift became known as the "Doppler effect" in honor of its founder. Although Doppler's observations dealt with audio frequencies, the effect is the same with microwave frequencies.

From the development of airborne radar during World War II, it was a natural step to the development of Doppler radar systems for aerial navigation. By monitoring the frequency shift in the radar return energy obtained by an aircraft as it moves over the surface of the earth, information vital to accurate navigation—ground speed and drift angle—can be obtained.

Doppler radar navigation, unlike other systems of navigation, employs dead reckoning techniques and is independent of en route visual references, ground stations, and weather. Also, it operates equally as well in any part of the world, over land or sea.

The energy generated by the airborne Doppler radar is concentrated into narrow beams which are directed toward the earth's surface at selected angles from the aircraft's horizontal, lateral, and vertical axes. The choice of angle varies with the equipment of different manufacturers. Usually two beams project forward and down, one to the left and one to the right of the horizontal axis of the aircraft; and similarly one or two beams project rearwards. The motion of the aircraft in relation to the earth's surface, in the three planes of motion, results in a difference in the frequency of the transmitted and received reflected energy in each of the beams. These frequency differences can be translated into the aircraft's motion and speed in the three planes.

With only one beam projecting forward, it would be possible to compute true ground speed, providing the aircraft was always in straight and level flight. With the information derived from the two forward and one rearward beams, it is possible to compute true ground speed and drift angle for all flight attitudes. The fourth beam, if used, provides a symmetrically balanced system with the inherent advantages of data redundancy for error checking and accuracy.

Other types of antenna systems are in use, but the preceding general description covers most commercial models.

ARINC (Aeronautical Radio, Incorporated) has established a general specification for Doppler system installations for commercial aircraft known as "ARINC 540."

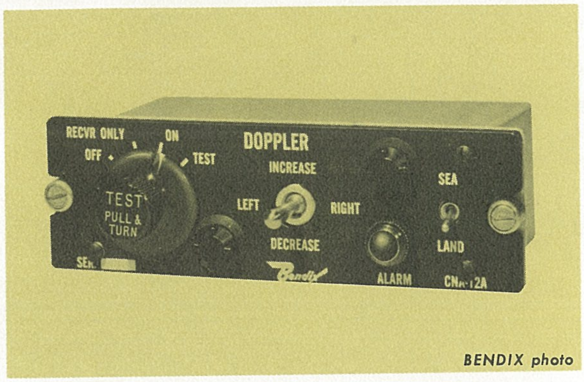
A typical Doppler radar navigation system currently in use on Convair commercial jet airliners is the Bendix DRA–12 Doppler Radar Navigation System. It is a four-beam FM/CW (Frequency Modulated/Continuous Wave) system operating on 8800 megacycles. This system is completely transistorized with the exception of the transmitting tube and its associated high-voltage power supply. The system consists of five major components: tracker unit, transmitter/receiver, indicator, control unit, and antenna.

The antenna is a thin four-beam planar array which may be rigidly attached to the aircraft structure. The greater portion of the antenna is only 3/4-inch thick, increasing to approximately 3-1/2 inches at its thickest point, enabling the antenna to be installed in a shallow recess. There are no moving parts in the antenna, a feature that permits a single antenna to be used for dual installation.

The transmitter tube, receiver, regulated power supply, transmitter modulation and frequency control circuitry, and the antenna beam switch control circuitry make up the transmitter/receiver package. The assembly is contained in a short 3/8-ATR (Air Transport Radio) case. A single microwave connection, with cabling, connects the unit to the antenna.

The tracker unit is a 1/2-ATR package that contains the tracker circuitry, the ground speed/drift angle computer, the output data servos, and the regulated power supplies. Transmitter power, receiver crystal current, and various power supply voltages are among the circuit functions that may be monitored by a meter and a rotary switch on the unit's front panel.

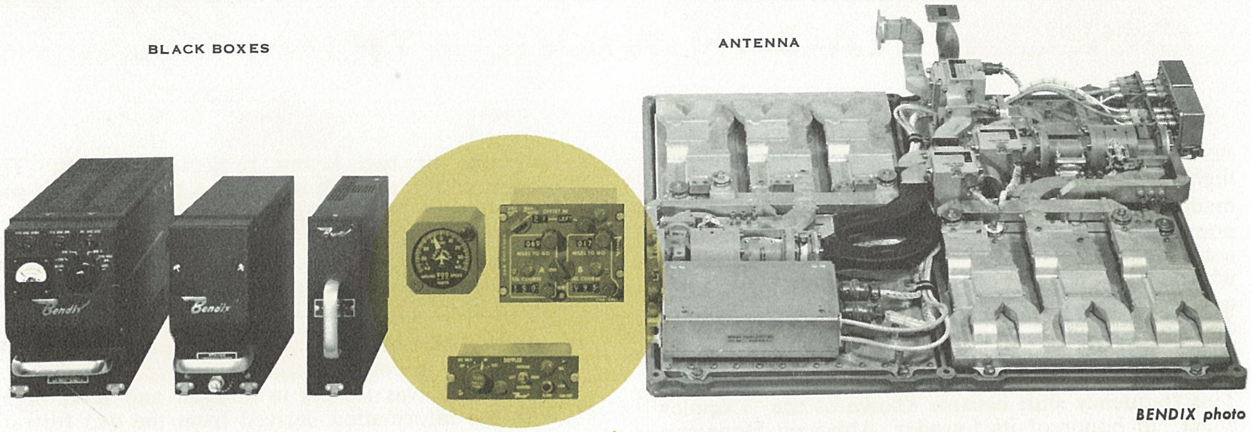
The indicator is in the form of a standard 3-inch diameter instrument. Drift angle up to ±40° is presented by a pointer and dial; ground speeds up to 999 knots are displayed by a three-drum digital readout. A repeater synchro operates the drift angle pointer; a servo system drives the ground speed counter. A flag alarm, together with a warning light, signals a lost data condition or any malfunction of the equipment.



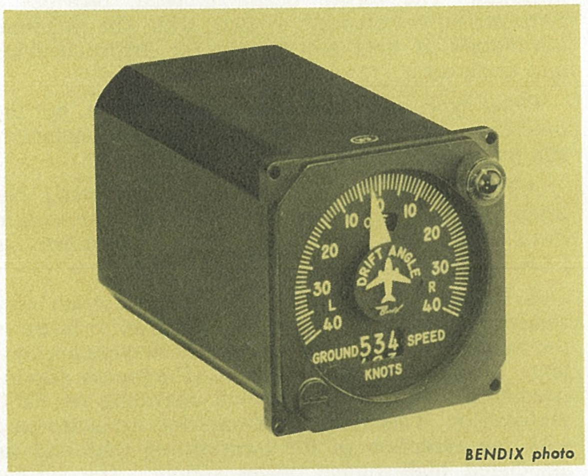
The CNA-12A pedestal-mounted control unit provides convenient, centralized array of all controls required to operate the basic Doppler navigation system.

BLACK BOXES

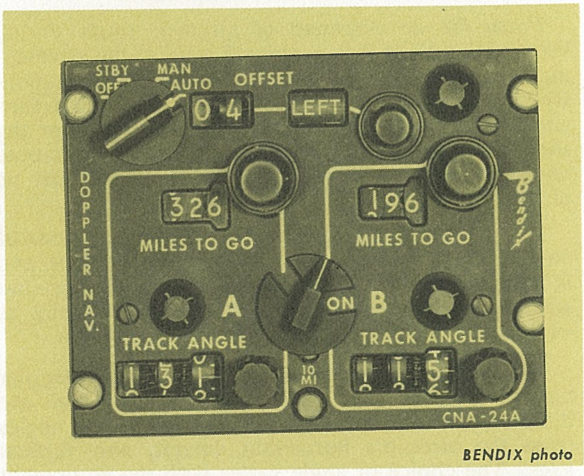
ANTENNA



BENDIX DRA-12/CPA-24 DOPPLER NAVIGATION SYSTEM



The Bendix INA-12A pilot's indicator provides direct readout of ground speeds up to 999 knots and drift angle Left or Right up to 40 degrees.



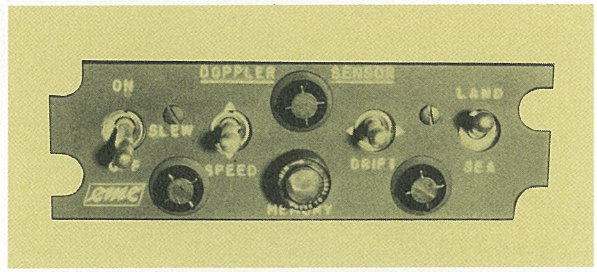
CNA-24A computer controller reads out miles-to-go to destination and miles L or R of selected track angle; it permits setting in "next leg" information.

The control unit, with all operating controls for the system, is designed for overhead panel installation. This unit consists of a function switch, a land-sea switch, and a servo-slewing control. A special test position of the function switch for system checking and an alarm light (parallel to the one on the indicator) are also included in the control unit.

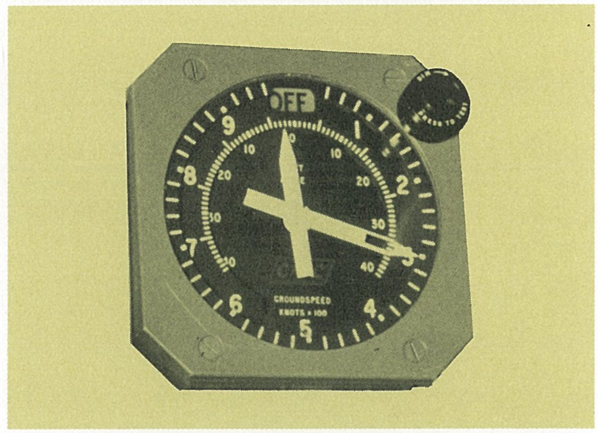
A CPA–24 Navigation Computer System that supplies accurate en route navigational information, such as miles-to-go to destination and miles off course, may be used as supplemental equipment with the DRA–12 Doppler radar navigation system. In addition to furnishing current and accurate navigational information, the computer system may also be used in conjunction with the aircraft autopilot so that a preselected course may be precisely maintained.

The combination of Doppler radar, navigation computer, and autopilot has proved to be one of the most accurate methods of aerial navigation yet devised. A preselected course may be maintained with little or no effort, and the navigational information is so conveniently presented that position based on selected magnetic heading may be determined in a matter of seconds.

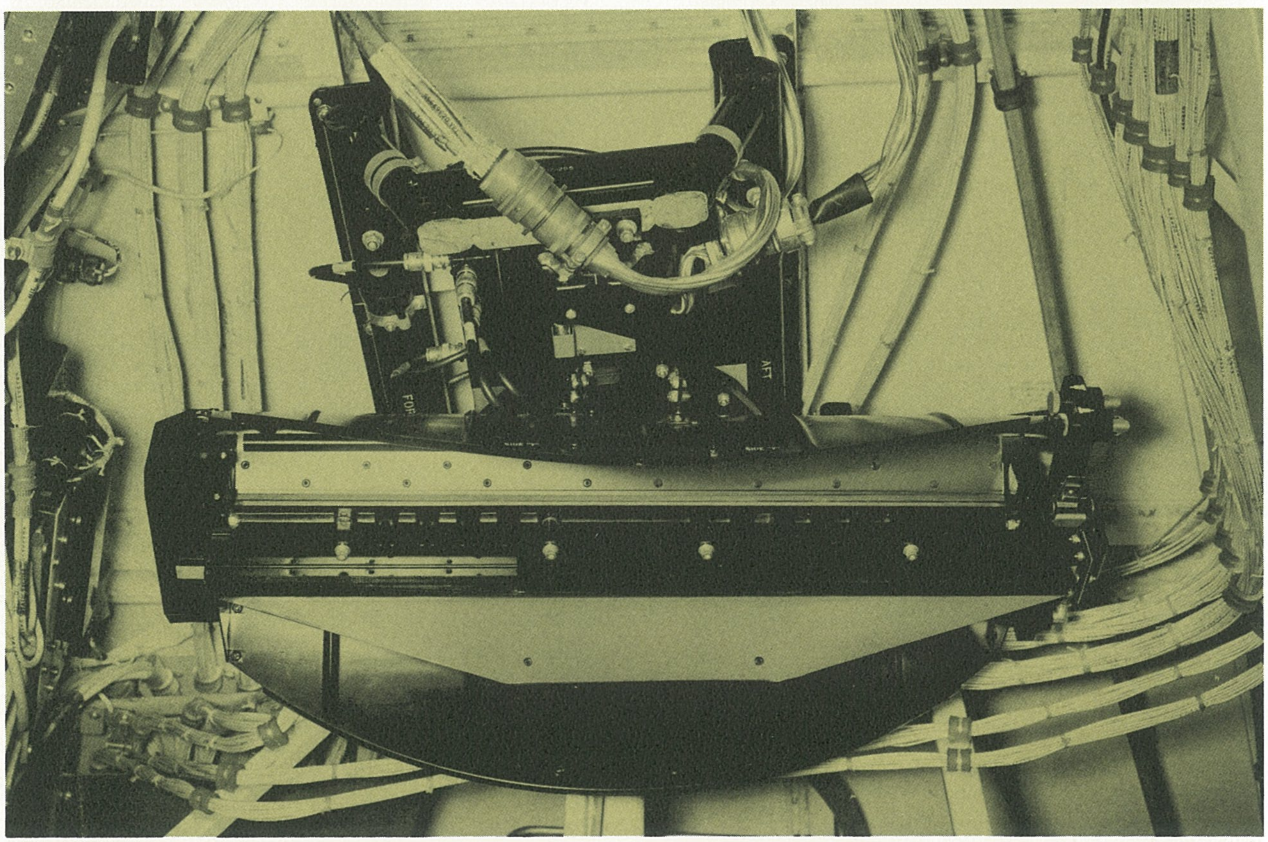
The navigation computer system that supplements the basic Doppler system consists of a computer and a computer controller. The computer is fitted into a 1/4–ATR (short) form factor case designed for radio equipment rack installation. The computer controller is designed for mounting on the instrument panel or radio control panel.



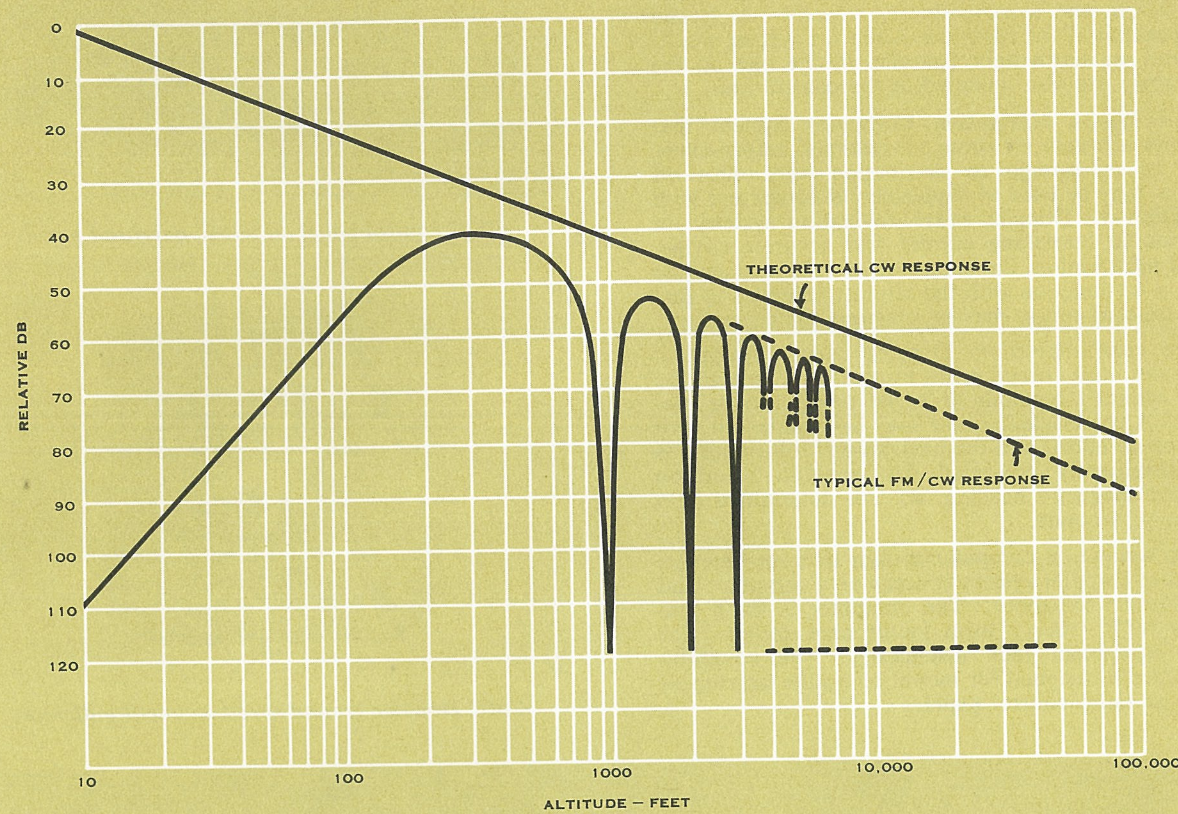
CMC control panel on pilots' overhead panel.



CMC Doppler ground speed and drift indicator.



CMC antenna in left-hand wing—looking upward.



Doppler signals are usually CW, pulse, or FM/CW. Pulse radar cannot operate at low altitudes. Both pulse and FM/CW are subject to "altitude holes." Above, for example, is a typical FM/CW response pattern, where the return signal fails at multiples of 1000 ft. above terrain. By a modulation technique, the DRA-12 eliminates altitude hole effect, retaining the advantages of FM/CW circuitry—simplicity, light weight, less power—and still, like CW, remains effective at all altitudes.

Ground speed information derived from the basic Doppler radar system is fed directly to the navigation computer system. The drift angle, also from the Doppler system, is first combined with heading information from the gyro stabilized compass system and then directed to the navigation computer as track-made-good. With this ground speed and track-made-good information, the navigation computer continuously and automatically computes ground position relative to track and point of origin.

The computer controller has two sets (stages) of TRACK ANGLE and MILES-TO-GO readouts on its panel. This duplicate arrangement is for use during long-range flights when it is necessary to break down the trip into two or more "legs." Information for the first leg of the flight can be set into the first stage, and information for the next leg can be set into the second stage. At the completion of the first leg, the controller automatically switches over to the next leg. The third leg can then be set into the first stage, and so on until the flight is completed.

Correction in erroneous preset information may be made to either stage of the computer controller during flight without affecting the accuracy of the readout information.

At the top of the computer controller panel is an OFFSET readout for LEFT or RIGHT of course, and another for indicating the number of miles off course. This offset information is applicable to the stage that is reading-out at the time. At the bottom of the panel is a small warning light that illuminates when the aircraft is within 10 miles of its destination.

Most Convair jet airliners, particularly the long-range versions, contain provisions for the installation of Doppler radar navigation systems. Some customers have already installed Doppler systems of one kind or another in their Convair equipment and are currently utilizing them to great advantage on regular scheduled routes. The trend indicates that other operators may follow suit.

FLIGHT CONTROL CABLES . . .

TWO TYPES OF CONTROL CABLES are used in the Convair 880/990 jet airliners—flexible and nonflexible. Flexible cables are used where a change of direction necessitates passing a cable over a pulley. Flexible cables, having more strands than nonflexible cables, permit greater flexibility; however, this flexing subjects the cable to greater strain and wear. Nonflexible cables are used in straight-run applications where high strength but little or no deflection is required. Since nonflexible cables are made up of fewer strands and are not required to change direction or to flex appreciably, fewer adjustments are required during their service life.

Both 7x7 and 7x19 flexible cables are used in the jet airliner flight control systems (see Figure 1). A 7x7 designation indicates a flexible cable consisting of 7 strands with 7 wires in each strand; a 7x19 cable has 7 strands with 19 wires in each strand. The cable diameter precedes the strand number: for example, 1/8x7x7.

Nonflexible cables are 1x19, consisting of 1 strand of 19 wires. All nonflex cables are 1/8 inch in diameter except for the straight run applications in the stabilizer control assembly, where 3/32-inch nonflex cables are used for mating with the 3/32-inch flex cables.

Sections of cables that pass through fairleads or around pulleys should be checked regularly for evidence of broken wires. Broken wires may be easily detected by rubbing the cables with a cloth—the cloth will snag on any broken wires.

Tests indicate that a few broken wires in a flexible cable will not result in a critical loss of its strength. As an example, a 7x7 cable may still carry its rated load with three broken wires within a 12-inch length. Flexible cables should be replaced if they have a greater number of broken wires per 12 inches, or if they have a broken wire within a section that goes over a pulley.

A 1x19 nonflexible cable should be replaced if it has one broken wire in the section that passes through a fairlead or over a pulley fairlead, or has a broken wire within a 10-foot length. Allowable damage is restricted because nonflex cables have less wires; therefore, each wire carries greater loads than do individual wires in flex cables.

Flexible and nonflexible cables should be replaced if they have a worn spot such that the individual wires have lost their identity (Figure 2). A nicked or cut cable should also be replaced. Any cable that has a broken wire in a free run should be carefully inspected for evidence of rust or corrosion. If rust or corrosion is evident, the cable should be replaced.

Figure 3 shows the wave tolerances permitted for serviceable cables. Cables with waves or bends exceeding these limits should be replaced.

Temporary fixes should never be applied to aircraft control cables. Clips and clamps affixed to cables in lieu of terminals and proper replacements result in a decrease in cable strength of as much as 50 percent.

Terminals are attached to control cables by swaging. This method of assembly cold-forms the terminal around the cable in a positive, permanent grip. A properly swaged connection will outlast the life of the cable. Figures 4, 5, and 6 show the allowable tolerances of swaged fittings.

A rotary swager or vertical press swager is recommended for cold-forming the terminal over the cable. The cable end is coated with SAE 10 lubricating oil before insertion into the terminal, and the terminal is lightly oiled before it is placed in the swaging die.

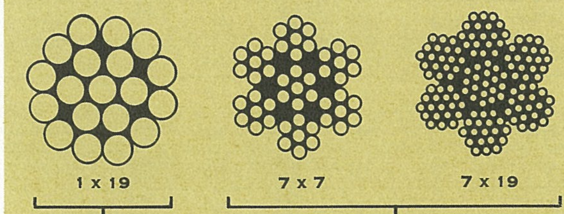


Figure 1. Types of cables.

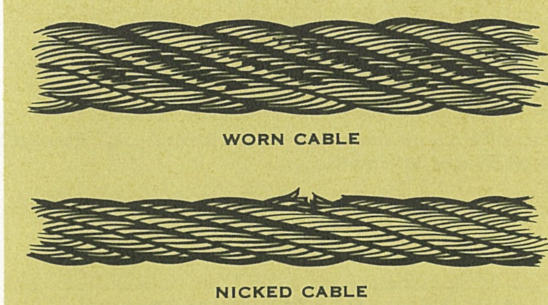
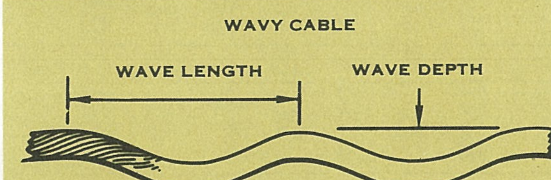


Figure 2. Cable damage requiring replacement.



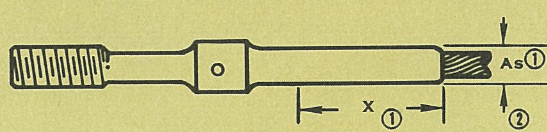
CABLE DIAMETER	WAVE LENGTH	WAVE DEPTH
3/32	1/2 Min	.010 Max
1/8	1/2 Min	.013 Max

Figure 3. Permissible wave tolerances.

TERMINAL DIMENSIONS—BEFORE AND AFTER SWAGING

③—AN658 – Fork End Cable Terminal   AN666 – Threaded Cable Terminal
AN677 – Fork End Cable Terminal   AN668 – Eye End Cable Terminal
AN669 – Turnbuckle Cable Terminal

NOMINAL CABLE DIAMETER	TERMINAL DASH NO.	(BEFORE SWAGING) A DIAMETER	(AFTER SWAGING) A_s ① DIAMETER	DIMENSION X ③ MINIMUM
1/16	2	.160 +.000 −.005	.138 +.000 −.005	.70
3/32	3	.218 +.000 −.005	.190 +.000 −.005	.80
1/8	4	.250 +.000 −.005	.219 +.000 −.005	1.05
5/32	5	.297 +.000 −.005	.250 +.000 −.005	1.29
3/16	6	.359 +.000 −.005	.313 +.000 −.005	1.31
7/32	7	.427 +.000 −.005	.375 +.000 −.007	1.55
1/4	8	.494 +.000 −.005	.438 +.000 −.007	1.70
9/32	9	.563 +.000 −.005	.500 +.000 −.008	1.89
5/16	10	.635 +.000 −.005	.563 +.000 −.008	2.06
3/8	12	.703 +.000 −.005	.625 +.000 −.008	3.15



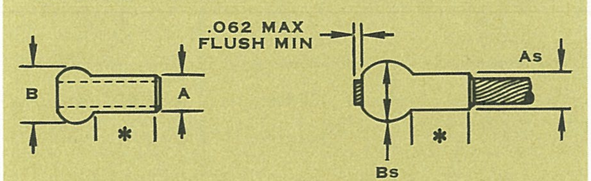
1. Swaged terminals shall conform to "A_s" diameter for length X.
2. Lead end after swaging may have double the tolerance given for the "A_s" diameter in area of original taper.
3. Dimension X is not applicable to AN658; check "A_s" diameter as specified on AN drawing.

Figure 4.

BALL TERMINAL AN664—SINGLE SHANK DIMENSIONS

NOMINAL CABLE DIAMETER	(BEFORE SWAGING) A DIAMETER	(AFTER SWAGING) A_s DIAMETER	(BEFORE SWAGING) B DIAMETER	(AFTER SWAGING) B_s SPHERICAL BALL DIAMETER
1/16	.132	.112	.212	.190
3/32	.168 +.000 −.004	.143 +.000 −.003	.282 +.000 −.004	.253 +.000 −.003
1/8	.223	.190	.350	.315
5/32	.259 +.000 −.004	.222 +.000 −.004	.424 +.000 −.004	.379 +.000 −.004
3/16	.298	.255	.492	.442
7/32	.352	.302	.560	.505 +.000 −.005
1/4	.406 +.000 −.005	.348 +.000 −.005	.629 +.000 −.005	.567
9/32	.444	.382	.699	.632 +.000 −.007
5/16	.480	.413	.768	.694

BEFORE SWAGING   AFTER SWAGING



✱ CHECK DIAMETERS IN THESE AREAS

Figure 5.

BALL TERMINAL AN663—DOUBLE SHANK DIMENSIONS

NOMINAL CABLE DIAMETER	(BEFORE SWAGING) A DIAMETER	(AFTER SWAGING) A_s DIAMETER	(BEFORE SWAGING) B DIAMETER	(AFTER SWAGING) B_s SPHERICAL BALL DIAMETER
1/16	.127	.112	.207	.190
3/32	.163	.143 +.000 −.003	.277	.253 +.000 −.003
1/8	.218 +.000 −.004	.190	.345 +.000 −.004	.315
5/32	.254	.222 +.000 −.004	.419	.379 +.000 −.004
3/16	.293	.255	.487	.442
7/32	.347 +.000 −.005	.302 +.000 −.005	.555	.505 +.000 −.005
1/4	.401	.348	.624 +.000 −.005	.567
9/32	.439 +.000 −.004	.382 +.000 −.007	.694	.632 +.000 −.007
5/16	.475 +.000 −.005	.413	.763	.694

BEFORE SWAGING   AFTER SWAGING

✱ CHECK DIAMETERS IN THESE AREAS

Figure 6.

The swager is started at low speed with the terminal barely inserted. It is speeded up while the terminal is rotated and being inserted. This process is repeated until the required terminal dimensions are obtained.

Swaged terminals should be smooth and free of cracks, splits, and weakening defects. If terminal cracking is encountered as a result of excessive cold-working during swaging, steps should be taken to reduce the number of impacts. On a rotary swager, the use of thicker shims will enable the terminal to reach final dimensions with fewer machine revolutions. On a vertical press swager, the dies and wedge feed should be adjusted to reduce the number of strokes to 25 or less.

Before swaging, the cable terminal joint must be marked with a harmless marker such as a colored pencil to establish a reference in case the cable slips. If slippage is apparent after swaging, the cable should be rejected. If the swaged terminal is marred by defects, cracks, or splits, the cable should be rejected. After swaging, a 1/2-degree bend is allowed in a terminal. A bend that exceeds this limit should be carefully straightened in a vise.

All cable assemblies are proof-tested and/or pre-stretched as part of their inspection before installation in the airplane. The cable-terminal joint is again marked with colored pencil for slippage reference, and the assembly is subjected to a force of 60 to 65 percent of its rated strength for a period of five sec-

PROOF-TESTED CABLE ASSEMBLIES—MIN. COIL DIAMETERS

CABLE DIAMETER INCHES	MINIMUM COIL DIAMETER INCHES	FEET
1/16	9	—
3/32	14	—
1/8 to 5/32	24	2
3/16 to 1/4	36	3
9/32 to 5/16	48	4
11/32 to 3/8	60	5

Figure 7.

onds. If there is visual indication of cable slippage within the terminal, the cable assembly is rejected. The assembly is also inspected for excessive stretching, broken strands, and terminal distortion — all causes for rejection. The cable assembly is satisfactory for use if terminal distortion does not exceed .001 inch per inch in the direction of proof-load application.

Prior to installation in the airplane or placement in stock, all aircraft control cables are treated with a corrosion-preventive, such as MIL–C–16173B, Grade I. This compound may be thinned with Stoddard solvent for ease of application. The recommended mix is four parts preventive compound to one part solvent. Cables must be free from dust and dirt before the compound is applied.

When installing the cables in the airplane, the corrosion-preventive compound is removed from those sections of cable that pass through rubber fairleads or pressure seals. These sections, after cleaning with a dry cloth, are lubricated with a general purpose low-temperature oil, meeting Specification MIL–L–7870A. On the 1/8-inch cables, the lubricating oil is applied over the corrosion-preventive compound for the full length of the section of cable that travels over pulleys and drums. The smaller cables do not require this application of oil. Should any of the compound be removed from the cables during handling or installation, it should be reapplied to the affected sections.

If cables are to be coiled for handling or stocking purposes, they should be coiled to the diameters shown in Figure 7. Cable assemblies should not be repeatedly coiled and uncoiled; handling them should be kept to a minimum. It is permissible to momentarily coil a cable to a smaller diameter than that indicated in the chart, if such a configuration would aid in assembly or installation. Coiled cables may be stored on rods or hooks if the surface in contact with the cable has a radius of four inches or more.

After installation in the airplane, cables should be rigged to the tension indicated on the applicable engineering drawing, or in the conversion table, Figure 8. This may be accomplished by the use of a cable tensiometer—a precision instrument that is individually calibrated to insure the utmost accuracy. The temperature in the immediate area of the checks must be taken into account. Two or three readings are generally taken at different locations along the cable, and the readings averaged to obtain more accurate tension values.

Tensiometers should be calibrated at least once a month to remedy any discrepancies in adjustment caused by normal usage. If a tensiometer has been dropped or has been subjected to unusual treatment, or if it gives an obviously erroneous reading, it should be recalibrated without further delay.

Proper maintenance and adjustment of cables should assure extended service life and relatively trouble-free operation.

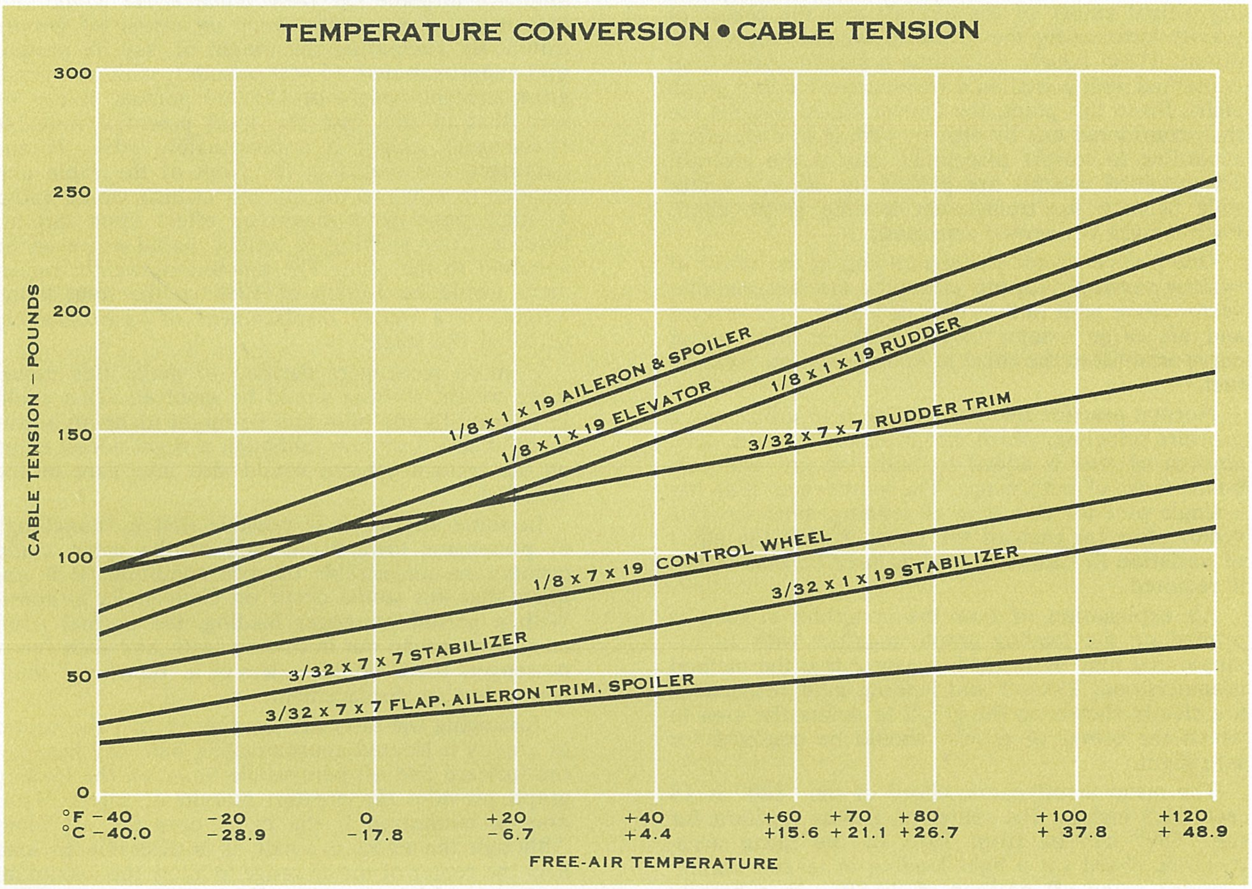


Figure 8.

CONVAIR 880 WEIGHT & BALANCE COMPUTATIONS . . .

Center of gravity location, before the advent of high speed jets, was not too important as long as the CG was within limits. With present high-speed jets, however, it is necessary to know the CG location at takeoff in order to know where to set the movable stabilizer.

Various operators utilize different means of determining the CG location; some use manual computations such as an index system (this is the basic system provided in the Convair weight and balance handbook); others use special loading devices. To fit the need of some operators, Convair has developed a balance computer which is a graphic method of determining CG. This device computes the effect of the variable loads by totalling the variable weight moment arms, and shows the effect of any loading combination on the airplane's center of gravity.

All that is needed initially is to know the operating weight empty of the aircraft and the center of gravity location for the operating weight empty condition. These figures determine a starting point that is marked with pencil on a transparent loading graph chart. From this point, the known added weights are then considered one by one, by adding in their effect according to weight placement aboard the aircraft. These added weights are plotted by using a vector slide beneath the transparent loading graph chart. Each weight is handled separately.

One plotted vector permits adding in the effect of various passenger seating within the aircraft. Another vector curve adds in the effect of loading the forward and aft cargo compartments, while a third vector curve establishes the effect of loading aboard required fuel.

Normal practice for fuel loading is to utilize equal pressure refueling, which means simply that the same amount of fuel is added to both inboard and outboard tanks of both wings. The load vector slide has a single plot for this type of loading, plus separate vector plots for each of the tanks so that the effect of variation in fuel tank loading may be determined if required.

An explanation of how the computer is used is printed on the loading graph, together with an example that may be worked to assure that the method is understood. Takeoff and landing limit restrictions are clearly shown on the graph to define the area to which the center of gravity should be confined for safe flight.

The mean aerodynamic chord of the "880" is 18 feet, 11.3 inches. The center of gravity position for the "880" can be from 19% of the mean aerodynamic chord (at a light loading in takeoff configuration) to an aft position of 29.5%. In a heavily loaded takeoff condition, the center of gravity may be varied safely from about 21% to 32%, depending upon total weight, disposition of fuel in tanks, etc.

Airline operators distribute the weight of the cargo to be carried between the forward and aft cargo compartments for best CG effect. This loading does not vary during a flight.

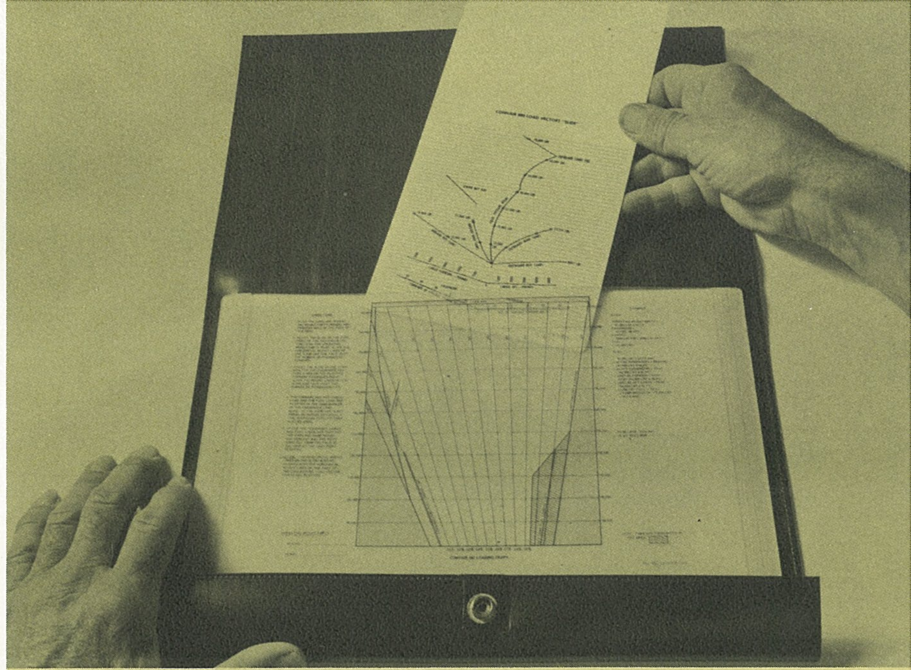
The initial fuel weight and its subsequent reduction through consumption during the flight affects the balance of the aircraft. Although the fuel weight may be proportionately large, it is disposed in the wing in such a manner that the fuel cg closely approximates the aircraft cg. Through the fuel crossfeed system, the flight engineer can supply any or all of the engines with fuel from any or all of the airplane fuel tanks and, by fuel management, can exercise airplane cg control.

The loading and movement of passengers will also influence airplane cg. *How much effect would this movement of passengers have on center of gravity travel?* By comparing the weight of, say 88 passengers (approximately 15,400 pounds), with an overall gross airplane weight of 155,000 pounds, it can be seen that in this case the total potential movable (passenger) weight is approximately 10%. If one passenger was seated in the front of the cabin and decided to move to the aft end (which would cause a single passenger's maximum effect upon aircraft balance), this shifting of weight would not even be apparent to the pilot. The amount of weight movement would be 1/88th of 10% of the total flying weight, or a weight displacement of approximately 0.1% of the total.

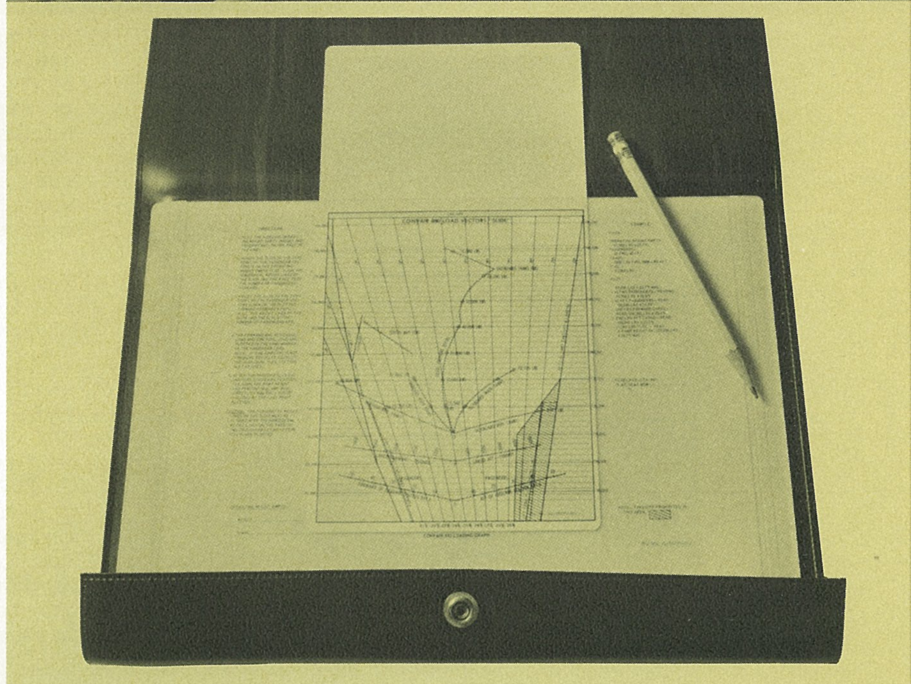
If more passengers decided to make this move, more weight shifting would be involved. This could be noticed by the pilot and he might make an adustment in stabilizer trim, although a slight added effort on the control column would also take care of the situation.

In some aircraft it is possible that a "bunching" of passengers toward one end of the cabin could produce an undesirable balance condition. It is unlikely that this would occur on Convair jet airliners. With a partial passenger loading, the normal tendency is to spread out in finding seats, and with fewer passengers there would be less of a "bunching" load; hence, less cg displacement.

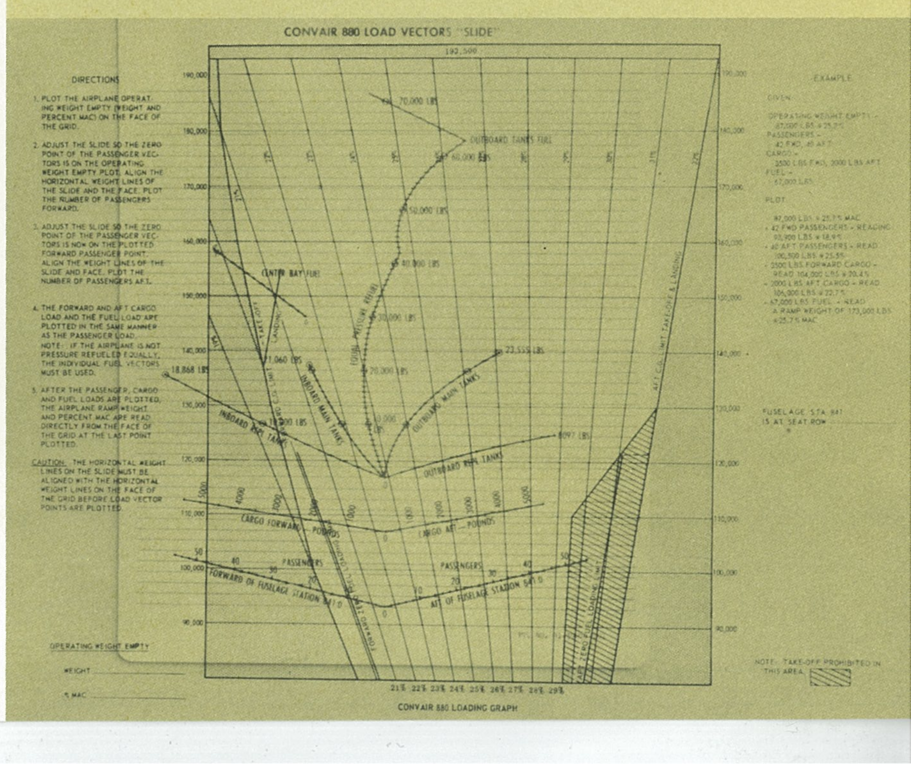
Arranging the aircraft's loading so that the center of gravity is located approximately half way between the forward and aft permissible limits on the loading graph provides the greatest margin of safety. Trim drag is minimized if the cg is near the aft limit. Although the effect is small, it is desirable to load near the center of the cg range to allow the maximum margin in either direction. With little compensating trim required, the best performance is achieved.



The balance computer load vector slide, held here in the right hand, has vectors for each of the loading factors: passenger seating, cargo loading, and fuel disposition. Each curve is marked in increments (passengers or pounds).

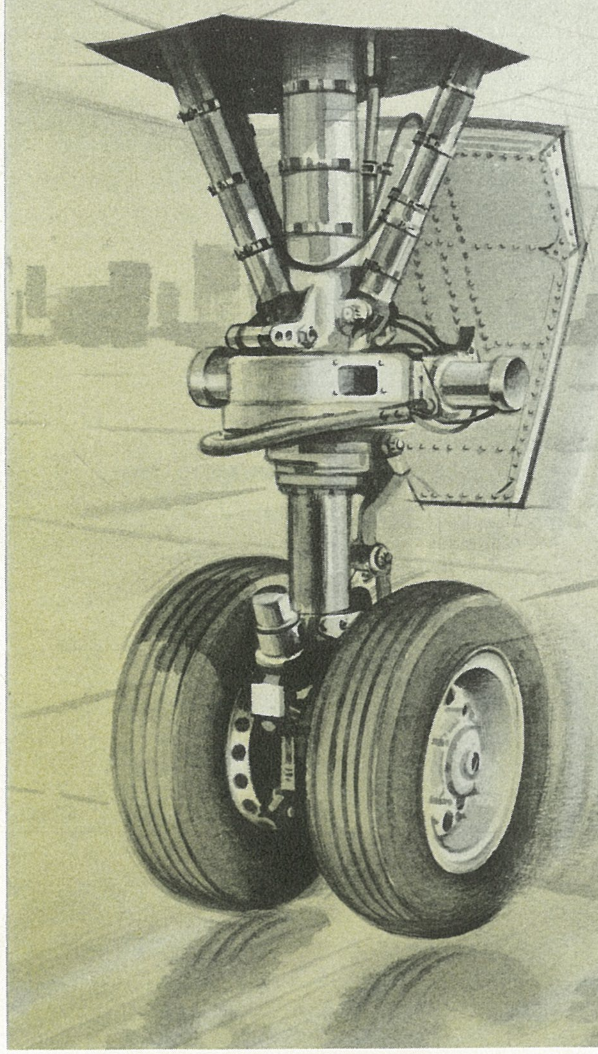


The load vector slide may be moved, as required, back of the center-of-gravity limitation transparent graph. This permits use of a pencil for marking center-of-gravity and weight as the aircraft loading factors are progressively added.



The center of gravity is located by the converging vertical lines on the computer; horizontal lines show the aircraft weight. Shaded portions of the computer define the CG limitations. Directions for use (with an example) are given.

MATCHING NOSE WHEEL TIRES...



PROPER MAINTENANCE OF NOSE WHEEL TIRES will permit good steering management. If one of the tires is softer than the other, the aircraft will tend to steer toward the soft tire, because of increased rolling friction and decreased rolling radius.

On the piston-engine Convair-Liners, tires were mated so that there was less than 0.5 inch wear difference. On the Convair 880, the comparable tire wear difference is 0.56 inch. All "880" operators, however, are proceeding on a basis of 1.2 inches circumferential difference as the maximum allowable, since this allowance has proved practicable through many months of service.

From a practical standpoint, it has been found desirable to match the nose gear tires with tires made by the same manufacturer, because of the difference in materials and fabrication. Under high-speed rotation, one tire may grow larger than one of a different make. Although both tires rotate at the same speed, the effect of centrifugal force may be more pronounced on the larger tire, causing it to wear more rapidly.

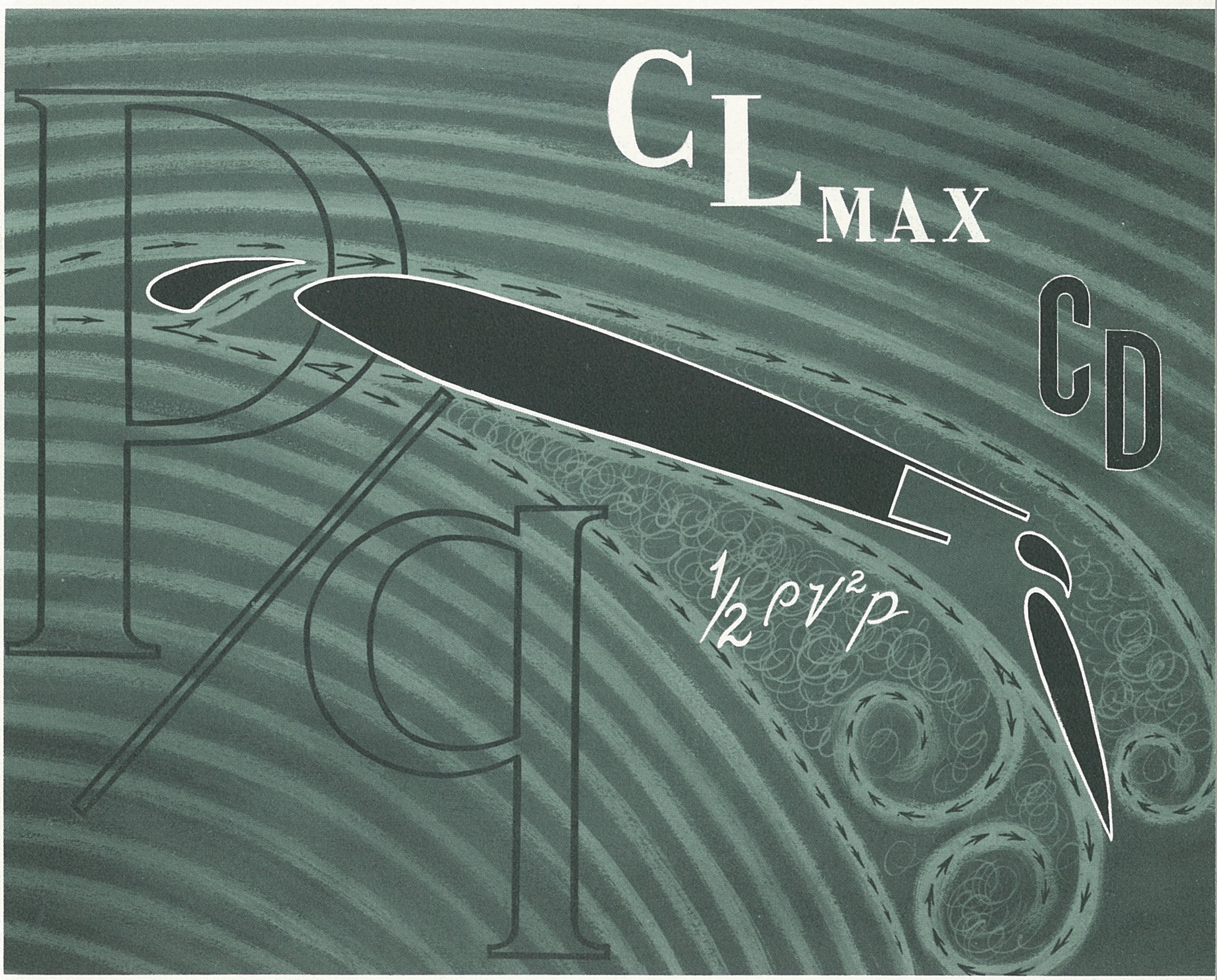
To maintain good steering, these points should be kept in mind: 1) equal tire inflation; 2) pairing of tires by amount of wear; 3) pairing tires by manufacturer.

Smooth gentle turns with a good radius are far easier on tires and gear. Abrupt and short radius turns, when maneuvering or towing the aircraft at low speeds, can produce considerable unnecessary wear on the tires. With high loads, short radius turns produce scuffing and consequent wear.

Abrupt turns at high rolling speeds can place considerable force on both tires and the supporting nose gear structure. It is reported that other large aircraft have actually incurred damage to the nose gear and supporting structure as a result of improper handling.

VOLUME XIII NUMBER 11 MARCH/APRIL 1962

Convair Traveler



In this Issue: Flap and Slat Systems—Convair 880/880M

OUR COVER

Reshaping a high-speed wing for low-speed efficiency demands solution of a thousand aerodynamic and mechanical problems. The mathematical complexity of designing a wing for landing is the theme of this issue's cover. Artist is Bob Kemp.

Convair Traveler

VOLUME XIII NUMBER 11 MARCH/APRIL 1962

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IN THIS ISSUE

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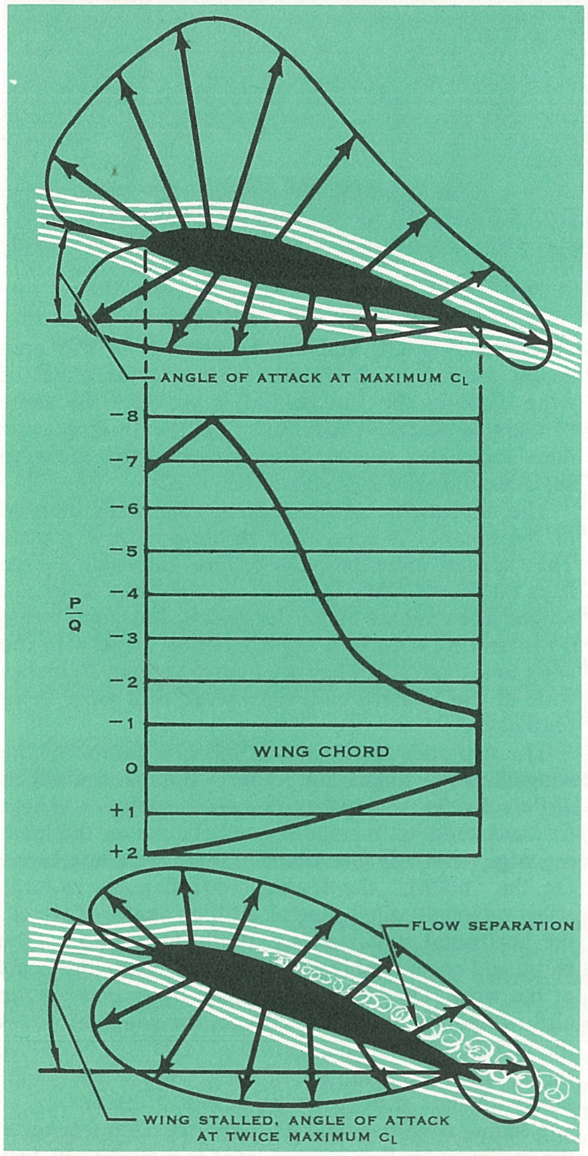
Flap & Slat System - Convair 880/880M



Pressure patterns on a typical light-airplane wing (NACA 4412) show loss of upper-surface lift as wing stalls. Middle graph is another way to chart such pressure patterns; this is type of chart that is used in the graph on the following page.

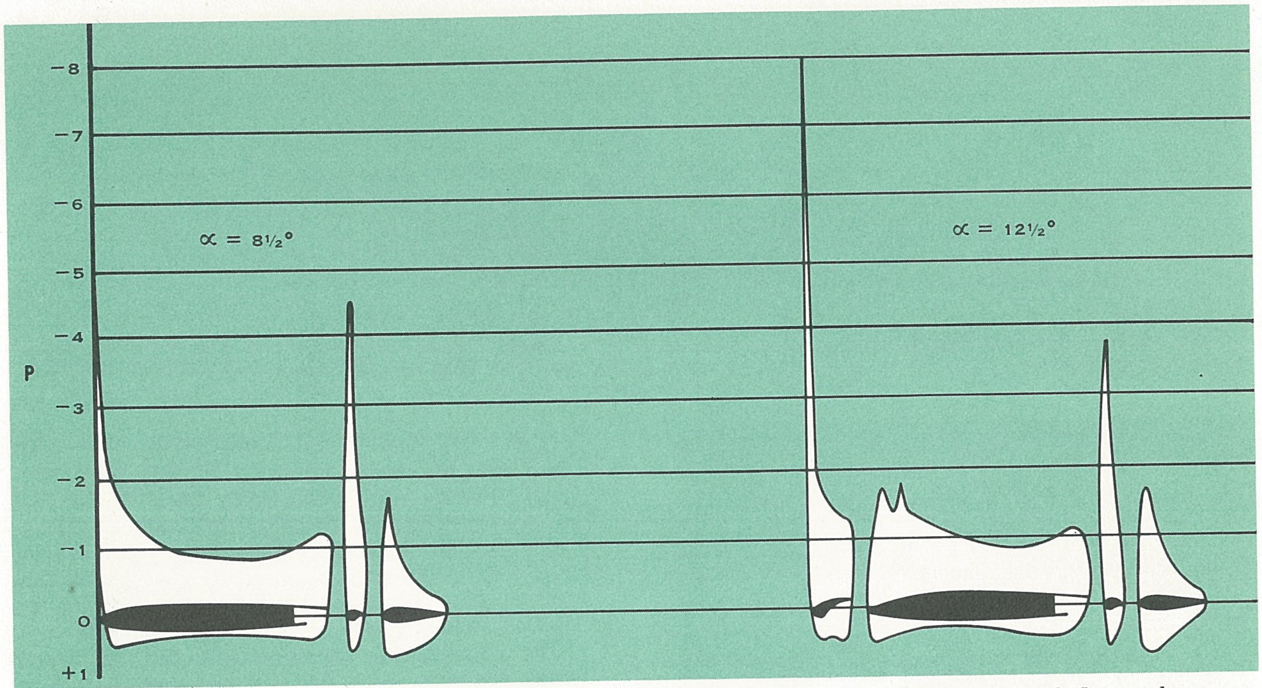
FLAP SYSTEMS on today's jet transports are more complex than ever before. Trailing edge flaps are larger, extend farther, and droop more. The Convair 880 flap area is more than the entire wing area of single-engine aircraft. Fully extended, the edge of the inboard flap of the Convair 880M is less than three feet from the ground. On most new designs, including the "880M," use is made of leading edge lift devices.

The aerodynamic considerations can be simply stated. Ideal *low-speed* high-lift wings are like those on gliders — long and narrow, comparatively thick, teardrop-shaped, with both upper and lower surfaces curving down at the trailing edge. More life comes from high-velocity airflow over the upper surface than from pressure on the lower surface. Patterns of forces on a typical airfoil are shown in the accompanying illustration.

The characteristics that best adapt a wing for *high-speed* flight — thin wing, sharp leading edge, sweepback, low aspect ratio, low camber, and minimal area — all have adverse effect on wing efficiency at low airspeed. The stall speed, in cruise configuration, of most aircraft capable of flying in the transonic speed range is too high to permit safe landing on average length runways.

Contemporary low-speed high-lift devices — trailing edge flaps, leading edge slats or flaps — can be viewed as measures to restore to the high-speed wing some of the low-speed characteristics. It is not practical to make a wing thicker, and sweepback or aspect ratio could be modified only with a variable geometry wing, much discussed but as yet undeveloped. Boundary layer control — use of airjets or suction to prevent airflow separation from the surface — is another area still under development. But it is possible to modify basic wing camber and increase wing area to achieve lower landing speeds. One device — the leading edge slat — besides adding to the wing camber, functions in part as a boundary layer control mechanism through its slot effect.

The purpose, in aerodynamic phraseology, is to increase maximum coefficient of lift. This statement sometimes misleads by conveying an impression that high-lift devices enable an airplane to lift more gross weight. *Maximum* lift must not be confused with maximum *coefficient* of lift. The highest value of the coefficient is at the lowest airspeed where lift is sufficient for flight. Increasing maximum coefficient of



Charts show typical pressure patterns at angles of attack near C_{Lmax} for swept wing with flaps only (left) and with slats added (right). Note angle of attack is almost 50% greater in right-hand graph.

lift, then, is lowering stall speed, and therefore takeoff and landing speeds, which, if not identical with stall speed, are directly dependent on it.

Trailing edge flaps are still the most effective single means for raising maximum coefficient of lift. They utilize all three of the lift-increasing measures — addition to wing area, increased camber, and slot effect. Extended beyond takeoff position, flaps add materially to airplane drag. The drag, too, is particularly useful to the jet airliner; the aerodynamic braking makes possible steeper approaches.

The Convair 880 obtains its necessary low-speed lift from trailing edge flaps alone. There are two on each wing, one inboard of the inboard engine and one between the engines. They are Fowler type, which, when extended aft as well as downward, add to wing area. All Convair jet airliner trailing edge flaps are slotted — in effect, double-slotted — with one slot between fore-flap and wing, and one between fore and main flaps. The fore-flap is a miniature airfoil and provides an appreciable vertical lift component. The slot behind it makes a converging nozzle, directing airflow along the main flap's highly cambered upper surface.

The "880M" has two types of leading edge devices —a modified Krueger-type flap between fuselage and inboard pylon, and extensible slats outboard of the inboard engines to the wing tip. The slats are airfoils, shaped to be part of the leading edge when retracted. They extend forward and down.

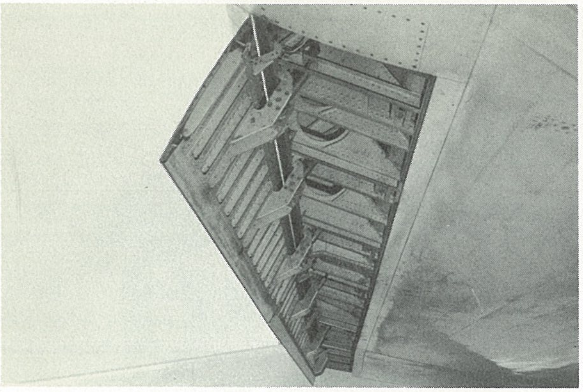
Leading edge devices, chiefly experimental in the past, have acquired importance recently. When the leading edge is thinned for high-speed flight, flow separation occurs more readily at high angles of attack. The pattern of aerodynamic forces on cambered wings shows leading edge lift to be a major portion of the total wing lift, and flow separation in this area causes more loss of lift. The slats add the effect of wing camber; the slot behind it provides the same converging nozzle effect noted in the trailing edge flaps, increasing velocity of the airflow across the wing surfaces and reducing separation.

The appearance of the leading edge flaps inboard of the engines is somewhat startling at first glance. They suggest mere flat-plate baffles. The leading edge flaps on the "880M" are in three segments. They are hinged a few inches aft of the leading edge, and swing down and forward to a slightly obtuse angle with the wing lower surface. They are approximately 20 inches wide at the inboard end, narrowing with wing taper outboard.

The flap adds to lift on the inboard section of the wing since the stagnation point — the point at which airflow divides to above and below the wing — is kept forward, tending to smooth out airflow over the leading edge, with less disturbance of the boundary layer. On the "880M," the leading edge flap has a large effect on longitudinal control. At high angles of attack, the horizontal stabilizer is partially blanketed by the wing, and considerably affected by airflow patterns aft of the wing. The leading edge flap, by smoothing the airflow over the inboard section of the wing, improves the effectiveness of the horizontal stabilizer, enabling the wing to take advantage of the low-speed lift obtainable with slats at higher wing angles of attack.

Leading edge slats and flaps are extended whenever the trailing edge flap control lever is moved to its first detent, so that they are always extended on takeoff and landing.

Takeoff position is marked 20° on the control lever in the "880," 22° in the "880M." Takeoff flap extension does not add much drag; it does add most of



Leading edge inboard flap is in three sections.

the increment of wing area; and it lowers minimum airspeed more than half the total possible. Flight manual charts show that at 130,000 lb gross weight, "880" stall speed is lowered from approximately 122 to 114 knots, and "880M" stall speed from 119 to 105 knots. It was proved during the flight test program that the aircraft would take off at slightly lower airspeed with 30° extension, but added drag slowed acceleration until ground run was about the same. This being no net gain, and requiring more airspeed buildup before retraction, the "880" was certificated for the lesser extension.

Above 30° extension, flap drag increases rapidly, and minimum airspeed decreases still more. At full extension, stall speed is about 6 knots less in both aircraft. The drag, as noted before, is useful in descent and touchdown; and a 6-knot decrease in stall speed is significant in performance. Ground roll is roughly proportional to the square of the touchdown airspeed. Using the figures quoted, full flaps would lessen landing roll of the "880" more than 20%, and of the "880M" approximately 30%.

Pilot use of flaps has been discussed in Traveler articles (May, June, July, and August of 1961) on "880" flight characteristics. As far as flying the airplane is concerned, there is little difference in flap management between the "880" and "880M." The latter is aided by larger flap area (which adds slightly to flaps-up wing area) and the leading edge devices, and is certified for takeoff at 8500 lb higher gross weight. At the same weight, it will take off and land at lower airspeeds, with somewhat greater angles of attack. On takeoff, when the "880M" reaches V_R (rotation speed), the nose will be lifted about 2° more than with an "880." The higher angle of attack requires a little more precision in takeoff, or in landing at the lowest possible speed, because of the possibility of dragging the tail.

Acceleration of the "880M" during second-segment climb (gear retracted, flaps still in takeoff position) is a little slower, because of the added drag of the leading edge devices and the higher angle of attack. Otherwise, pilots report little difference in feel or controlability of the two aircraft.

TRAILING EDGE FLAP MECHANISMS

The "880" and "880M" trailing edge flaps are supported by roller carriages, riding on steel tracks curved in an arc to deflect the flaps as they extend. From purely aerodynamic considerations, the arc path is not optimum. Ideally, the flaps should extend aft for takeoff lift, and then down for landing purposes. But a glance at the size of the aerodynamic loads on flaps, as shown in the accompanying illustrations, shows that there is quite a cantilever loading to be handled, and the arc is a practical compromise with weight and structure considerations.

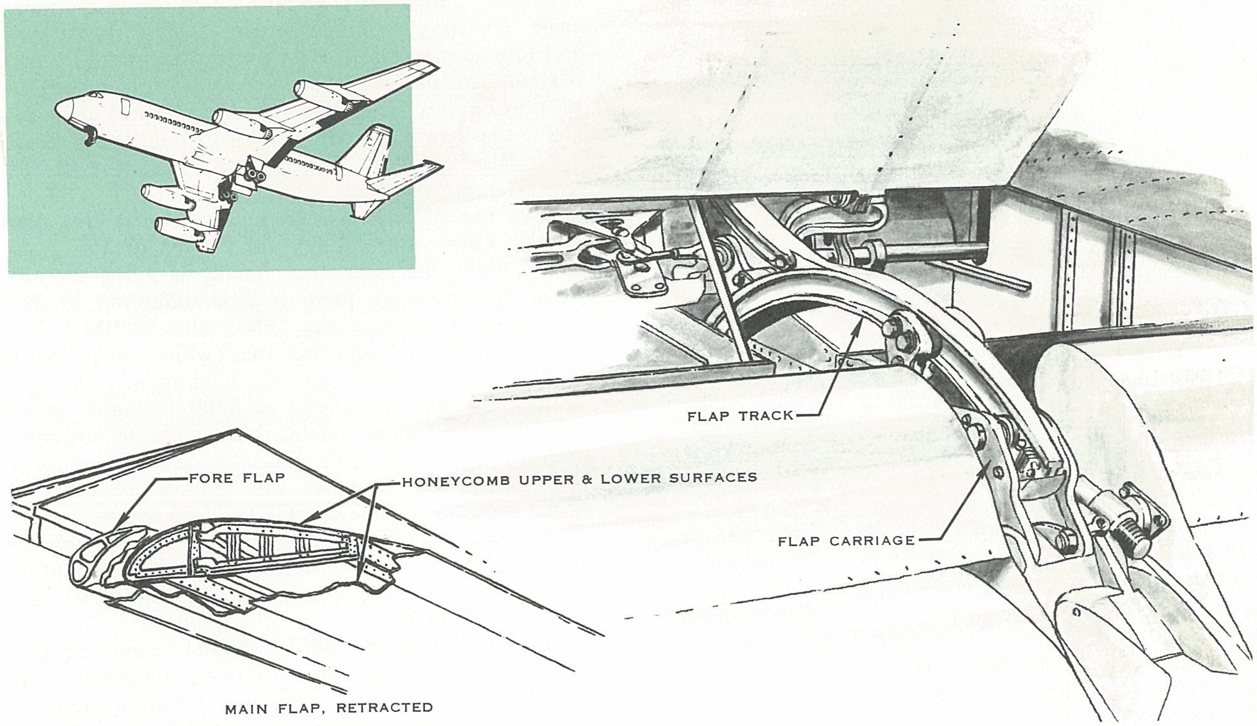
There are two tracks for inboard flaps, three for outboard. The extension mechanisms are recirculating-ball screwjacks, two for each flap, all actuated by a single torque tube for each wing, driven by hydraulic motors at the airplane centerline.

"No-backs" — irreversible clutches — are part of each screwjack mechanism. They are necessary to prevent the airstream forcing the flaps up by driving the ballnuts on the screwjacks. The higher the air pressure on the flaps, the tighter must be the locking action of the no-backs, and the greater the breakout force required to begin retraction. More continuous power is required to extend the flaps to large angles than to retract them. The greatest power requirement, however, is the breakout force necessary to begin flap retraction, when the airplane is near the flap speed limitations.

The "880M" outboard flaps are identical with those on the "880." The inboard flap is larger, with more than 10 inches span added inboard; the inboard edge is also 10 inches longer. The "880" inboard flaps have a maximum deflection of 50°. The "880" flap control quadrant is marked in increments of 20°, 30°, 40°, and 50°, with lever detents at each position. The "880M" inboard flap deflects to 55°, and the detent markings read 22°, 33°, 44°, and 55°.

The only difference in the wing mechanisms between the "880" and "880M" is that the inboard actuator of the inboard flap is slightly larger in the "880M." There is a difference in the control mechanism. In the "880," the torque tubes are driven by two hydraulic motors, each powered by one of the two hydraulic systems. The motors are constant-displacement piston-type, and turn the torque tubes through a gearbox with approximately a 4.7:1 gear ratio. In the event of failure of one hydraulic system, "880" flap extension is slower than with both motors operating. Since the "880's" first went into service, Convair has provided higher-torque motors, and the currently operating "880's" have faster full-down extension and retraction in single-system operation. Extension speed is about twice that for retraction.

The "880M," though it also has two hydraulic motors each powered by different hydraulic systems, operates the flaps with only one of the motors. This provides a fully-powered backup in case of hydraulic failure of one system. A "flap power select" switch on the overhead panel selects the hydraulic system. NORM position of the switch is for the No. 1 system; ALTER position is for the No. 2 system. Though



Trailing edge main flaps, stowed, are part of trailing edge. Flaps extend aft and deflect downward.

labeled "alternate," No. 2 system operation is intended for backup only. Using this mode of operation entails some cavitation in the No. 1 side of the actuator, and prolonged usage might cause component damage. The hydraulic motors have identical power output.

In both "880" and "880M," hydraulic power is controlled by a dual selector valve, with a quadrant to which cables run from the cockpit pedestal quadrant. A follow-up linkage cuts off hydraulic flow when the flaps have reached the position set by the flap control lever. The selector valves are spring-loaded to neutral position; a failure in the follow-up linkage or in the control cable system would cause the flaps to lock in the position in which they were selected.

There are, however, two additional safeguards designed into the system. Upstream of the selector valve in each hydraulic pressure line are solenoid-operated cutoff valves, usually termed "flap phase" valves. They are spring-loaded open and must be energized to shut off hydraulic pressure to the motors. At the outboard end of each torque tube are asymmetry switches, which are in effect rotary electrical contacts so aligned as to be normally out of phase. If flaps on one wing lock or drag to the point where contacts close in both switches at once (approximately 2° differential), a relay delivers power to the phase valves and so closes them, locking the flaps at that point.

The other safety device is a trigger switch on the flap control lever, energized only when the lever is moved from a detent, and coupled to a limit switch at the selector valve. Power is cut off to open the phase valves only when the flap lever is out of its detent, or during flap travel, before the follow-up has closed the selector valve and opened the limit switch. With the flaps at their selected position and the flap control lever in a detent, the circuit is closed and the phase valves energized to the closed position, removing hydraulic power.

Operation in this second circuit is not an essential flight safety item, and, on occasion, it has been deactivated, with FAA consent, on the grounds that it protects only against cable breakage or follow-up disconnect, both unlikely to occur and already protected against by the selector valve centering spring.

The outboard flaps add enough lift to the outboard portion of the wings to move wing center of lift aft. To counteract this, the spoiler actuating mechanism is tied in with the flap system so that outboard spoilers are partially extended when the flaps extend more than 35°. Maximum spoiler deflection, when flaps are extended beyond 35°, is 6° in the "880," 8° in the "880M."

The flap-spoiler interconnect is at the wing "break" point, where the flap torque tube goes through an angle gearbox to follow the sweepback to the trailing edge. A crank on the gearbox upper surface actuates the spoiler control rod to raise the outboard spoilers slightly as the flaps move beyond 35° extension.

Warning horn circuits through switches mounted on the central drive gearbox, landing gear, and engine control levers, cause the horn to sound for unsafe flap conditions for takeoff or touchdown. On the ground, if the flaps are in any position other than takeoff, and if two power levers are advanced beyond 92% rpm, the horn will sound intermittently. During landing, if the flaps are lowered beyond 43° and any landing gear is not down and locked, the horn sounds continuously.

"880M" LEADING EDGE MECHANISMS

The "880M" leading edge flaps and slats are extended by screwjacks, driven by hydraulic motors near the airplane centerline. The screwjacks are also protected against aerodynamic extension by no-backs. There are four slats in each wing, two inboard and two outboard of the outboard pylon. All, being part of the leading edge, are anti-iced through telescoping conduit by engine bleed air. They extend on true radius arc tracks. Leading edge flaps are extended by screwjacks that extend the flaps down and forward on the forward hinges.

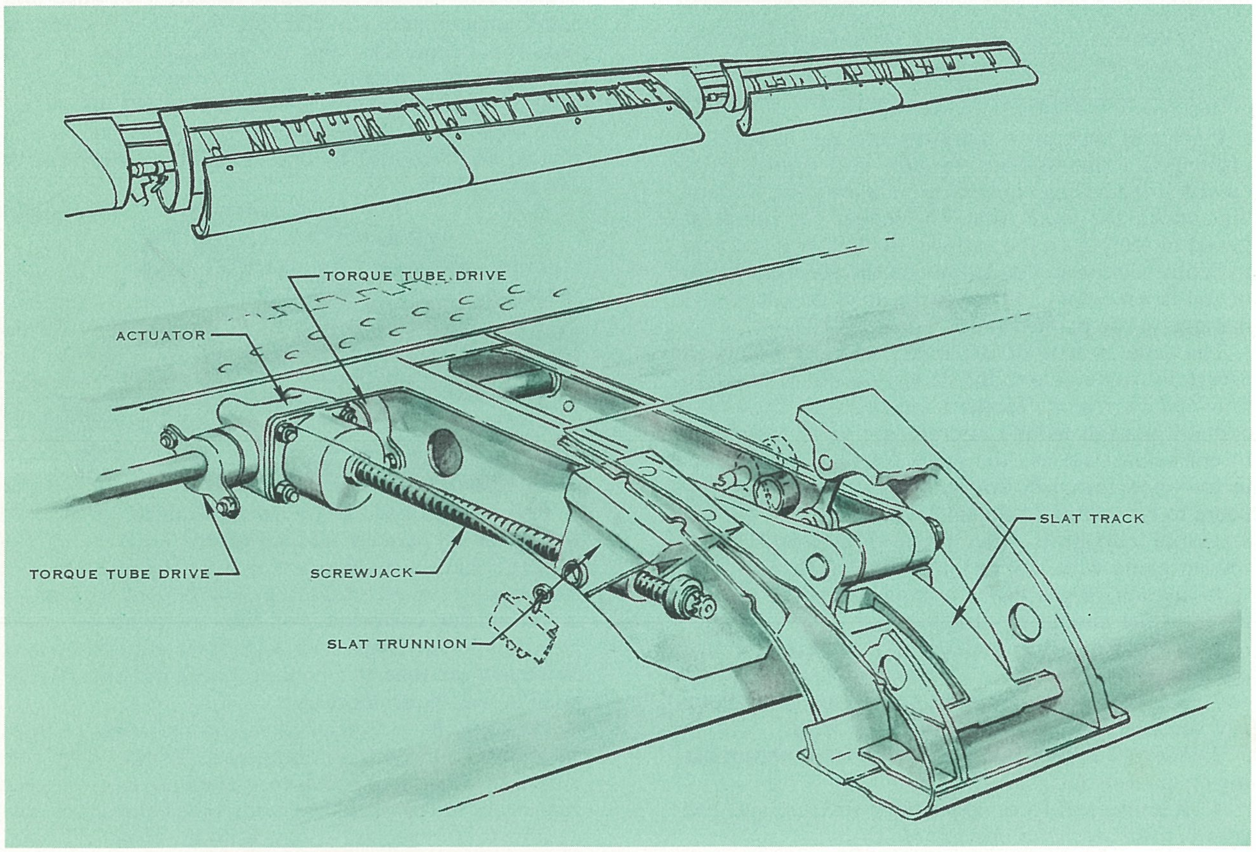
The hydraulic motors in the "880M" leading edge flap and slat drive system are powered by two hydraulic systems and operate together, as in "880" trailing edge flap actuation. Either motor alone will extend slats and leading edge flaps. The angle drive gear-box is at the wing root; outboard of it is a reduction gearbox with dual outputs. One output shaft drives the slats in a 2:1 gear reduction ratio; the other drives the leading edge flaps in a 2½:1 gear ratio. The reduction gearbox also contains a slip clutch to limit hydraulic power to individual screwjacks in the event they should jam.

Extension is controlled through a loop in one of the trailing edge flap control cables from the cockpit pedestal quadrant. The cable turns a cam that operates a dual system hydraulic selector valve, which controls hydraulic flow to the motors. There is no intermediate stopping point in extending the leading edge devices. A follow-up linkage stops hydraulic flow when the slats and flaps have reached full extension.

The selector valve extends the slats and leading edge flaps when the flap control lever is moved approximately one-quarter of the way toward the 22° first detent, and retracts as the lever is moved about a quarter of the way from the detent toward zero. The linkage is designed so that slat travel is instantly reversible if the lever is reversed. The selector valve is spring-loaded to neutral to hold the slats and leading edge flaps in place in the event of a mechanical malfunction causing loss of manual control.

Trailing edge flap position is shown on a position indicator on the center instrument panel. The position transmitters are located on the asymmetry switch housings at the outboard ends of the torque tubes. The indicator dial has two needles, a narrow white one for left-hand flaps superimposed over a broader red-bordered needle for the right wing. The pointers show as a single pattern of white bordered with red, when extension is symmetrical; when asymmetrical, the second pointer becomes visible.

Leading edge flap and slat extension is indicated by two pairs of lights on the center instrument panel. Two amber in-transit lights, one for each wing, illuminate when any leading edge flap or slat begins to extend. When all slats and leading edge flaps are extended, the amber lights extinguish and two green lights illuminate.

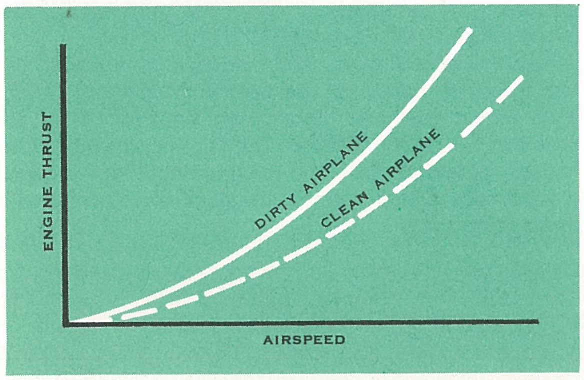


Screwjacks extend slats forward and downward in a 15° arc. Slats ride on rollers on curved tracks.

Cleaning the Airplane Exterior

KEEPING AN AIRLINER LOOKING NEW is about as important as keeping it in tip-top operating condition. The traveling public cannot see much of the mechanisms and systems of the airplane, and take the successful operation of such things for granted, but they are greatly impressed by the overall appearance of the aircraft in which they plan to fly. Travelers have been known to cancel their flights at the last minute when they didn't like the looks of the airliner they were about to board.

A clean airplane promotes favorable impressions and instills confidence in the air traveling public, but there are other reasons just as important for maintaining airliner equipment in spotless condition. A clean airplane flies better because a clean smooth surface presents less drag than does a soiled surface; and dirt, after a period of time, may work its way into vital mechanisms to hamper their operation.



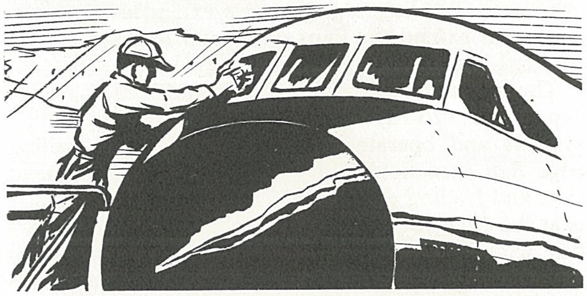
Paint and decorative markings are also affected by prolonged accumulations of dirt and grime, particularly if the soiling contains mineral or solvent agents that attack the paint film. The longer the soil is allowed to remain on the surface, the longer it will take to finally remove it. Oxidation and the chemical action of soil-laden paint can change the color and do lasting damage to the painted finish.

The same is true of unpainted surfaces which are especially vulnerable to the damaging effects of oxidation and corrosion. Modern metals, with high alloy content, used in today's aircraft, are more susceptible to corrosion than are the more familiar alclads used in low-speed aircraft. An aluminum surface that appears to be stained or dulled may be entering the first stages of corrosion. The discoloring should be removed along with any pitting of the surface.

In maintaining a clean airplane exterior, the following rules should be observed:

1. Keep all surfaces clean and protected against oxidation.
2. Keep landing gear, pods, pylons, wings, and control surfaces free of oil and hydraulic fluid.
3. Prevent engine exhaust residue from accumulating on exterior surfaces.
4. Remove soil from upper wing surface, and elsewhere, after servicing operations.
5. Clean windows prior to each flight.

There are three methods of cleaning the aircraft exterior — *wet wash, dry wash,* and *polishing*. Polishing can be further broken down into hand polishing, mechanical polishing, and removal of corrosion. The type and extent of the soiling and the final desired appearance determine the method of cleaning to be employed.



Wet wash removes oil, grease, and carbon deposits, and most soils, with the exception of corrosion and oxide films. The cleaning compounds used in wet washing are usually applied by spray or mop, after which high-pressure running water is used as a rinse. Either alkaline or emulsion cleaning compounds may be used in the wet wash method — alkaline for painted and unpainted surfaces, and emulsion for heavy deposits such as carbon, grease, oil, and tar.

Dry wash is used to remove airport film, dust, and small accumulations of dirt and soil when the use of liquids is neither desirable nor practical. This method is not suitable for removing heavy deposits of carbon, grease, or oil, especially in the engine exhaust areas. Dry wash materials are applied with spray, mops, and cloths, and removed by dry mopping or wiping with clean dry cloths.

Polishing by hand or by mechanical means restores the luster to painted and unpainted surfaces of the airplane, and is usually performed after the surfaces have been cleaned. Polishing is also used to remove oxidation and corrosion. Polishing materials are available in various forms and degrees of abrasiveness. It is important that the correct polishing material be used in specific applications.

Polishing by action of chemical materials restores brilliance to aircraft surfaces, and removes corrosive products. Chemical polish is applied after the surface has been wet-washed. As with other polishing materials, it is important to use only the chemical compound approved for a particular application.

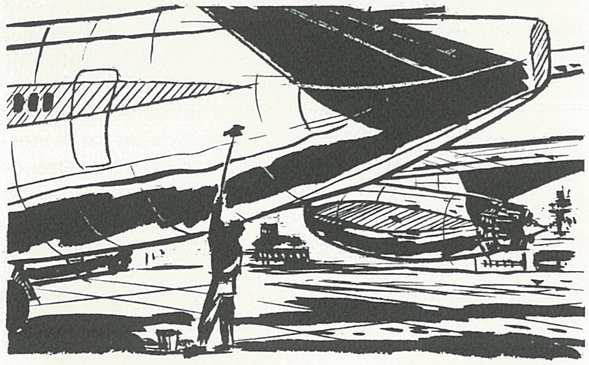
Emulsion type cleaners contain solvents that are especially useful in removing oil, grease, and heavier types of soil deposits. The dissolving action of the hydrocarbons, together with the detergent agents in the emulsion cleaner, loosens the grease and soil particles and prevents their redeposition during cleaning and rinsing.

Alkaline cleaners are basically water-based solutions that are particularly adaptable to hard water use. They prevent deposition of hard water salts on surfaces being cleaned, have corrosion inhibiting properties, and are excellent cleaners of light oily deposits and airport films. They are also effective on light deposits of engine exhaust residue.

Alkaline cleaners have several advantages over emulsion cleaners: 1) they are not toxic or flammable and can be safely used indoors; 2) cleaning and rinsing provide no waste disposal problems; 3) they are less deleterious to plastic and rubber surfaces; 4) they do not discolor or soften painted surfaces or decals; and 5) they do not reduce reflective properties of white paint coatings.

The following list of precautions should be observed when working with emulsion and alkaline cleaners:

1. Do not apply cleaner to areas that are too large to brush and rinse before cleaner dries on the surface. The best results are obtained when the cleaner is rinsed from the surface while still wet.
2. Be sure that all cleaners and solutions are well mixed, prior to use.
3. Do not allow the cleaners to come in contact with lubricated parts, such as actuators and bearings, because the grease will become diluted, and bearing damage may result.
4. Do not allow emulsion type cleaners (in any strength) or undiluted alkaline type cleaners to come in contact with plastic windows or other thermoplastic parts. If alkaline cleaners are to be used on these plastics, use only diluted solutions mixed according to specifications.



5. Do not use emulsion cleaners or undiluted alkaline cleaners on the tops of aircraft if there is a possibility that the solution might run down the sides of the fuselage and onto the plastic windows.
6. Do not use shop cloths for polishing plastic windows, because surface may be scratched by metal chips and filings embedded in the cloths.
7. If mop or cloth should fall to the ground, use clean one to eliminate the possibility of scratching surface with objects picked up from the ground.
8. If the entire airplane is to be cleaned, spray the whole surface with water; then, wash up and rinse down. If a steam gun is used in the wet wash operation, hold nozzle at least 12 inches from the surface being cleaned.
9. Do not use an atomizing spray to apply cleaners. A coarse, high-pressure spray will clean more effectively, reduce waste, and preclude the health hazard of an inhalable mist.
10. Avoid spraying cleaners on electrical conduits, electrical units, junction boxes, or on readily absorbent materials. If spray enters junction box, the box should be opened and the interior dried.
11. To prevent water and other liquids from entering vital areas and damaging components, observe the following precautionary steps before commencing to wet-wash the airplane: a) install well covers; b) close all emergency exits, cabin doors, cargo compartment doors, and access doors; c) close pitot static openings with a piece of masking tape and attach a long red streamer; d) securely close fuel and oil tank filler caps; e) install vent plugs to prevent water and other liquids from entering fuel tanks; f) install protective covers over intake and exhaust openings.
12. Protect the anti-corrosive coatings on brake discs and engines so that they do not come in contact with petroleum solvents and emulsion cleaners.
13. Keep the stronger emulsion cleaners, which are capable of removing paint, from contacting enamel, lacquer, other paints, rubber, sealed stress plates, fuel tanks, plastic windows, and other thermoplastic materials.
14. Do not let tires stand in pools of petroleum solvent or solutions of emulsion cleaner and solvent.
15. If areas are cleaned with paint-remover type emulsions, go over the area with aluminum polish.
16. Keep containers of paint-remover type emulsions tightly closed when not in use, because solvents will evaporate and render the materials ineffective.
17. Exercise extreme care when using the stronger emulsion cleaners, such as those used for removing stubborn carbon deposits, to prevent spilling the solution on the skin. If the cleaner should touch the skin, eyes, or clothing, wash off immediately with quantities of water, and seek medical aid.
18. Avoid prolonged breathing of the solvent vapors of emulsion cleaners. Allow sufficient ventilation and have adequate fire extinguishers handy.
19. Wear adequate protective clothing — gloves, aprons, boots, face shield, and eye protection.

20. Do not use alkaline and emulsion cleaners for engine maintenance cleaning. Emulsion cleaners, however, may be used for degreasing engines during overhaul.

21. Petroleum solvents used with emulsion cleaners are flammable; therefore, do not use in engine areas while engines are hot. All traces of these solutions must be removed from the engine before operation.

22. Always park pressure tank unit or wet wash truck upwind of aircraft to eliminate fire hazard, if flammable solutions are used; keep spray off truck, nearby aircraft, or other equipment.

23. Do not use acid cleaners. All acids are prohibited because of danger from hydrogen embrittlement of high strength steels.

Alkaline cleaners are equally adequate for cleaning the entire airplane. The strength of the solution may be varied to cope with different degrees of soil and oil/grease deposits. In areas of heavy soil, oil/grease, and cabin residue, however, emulsion cleaners may be required for the complete removal of residue.

For general painted and unpainted areas, an alkaline solution consisting of one part cleaner to five to ten parts water will usually prove sufficient. Exhaust areas, flap wells, and wheel wells may require a stronger solution of one part cleaner to three parts water, which will cleanse most oil and greasy accumulations. Soils that are extremely difficult to cut may require undiluted alkaline cleaner, or the stronger emulsion cleaning solution.

Areas soiled by exhaust residue may be cleaned by a mixture of one part heavy duty emulsion cleaner with four parts water or petroleum base solvent. The solution is mopped or wiped on the area; after a 20-minute dwell period, it is rinsed off with water.

Polishing unpainted aluminum surfaces by hand may be accomplished by the application of polishing compounds, impregnated polishing pads, or liquid solutions. The polishing compounds and the impregnated pads are applied to the surface in a straight motion (not circular) until all embedded dirt and oxide are removed. The surface is then polished to a bright shine with clean mops or cloths.

Liquid aluminum polish may be applied to the unpainted surface by two methods — a method normally used, and a fast method. In the normal manner, the liquid polish is spread over the surface in full strength, rubbed with straight strokes until all embedded dirt and oxide are removed, and then polished to a shiny finish. To polish the airplane using the fast method, the liquid polish is applied to the surface in a solution consisting of two parts polish and one part clear water. This solution is rubbed over the surface in either straight or circular strokes, and the brightening is done while the surface is still wet. It is necessary to work one small area (approximately 10 feet by 10 feet) at a time to prevent the solution from drying before attaining the brilliance required. The final polishing is done with clean dry mops or cloths.

Plastic windows require care in cleaning. Most sprays are injurious to plastics since they contain chemicals that have a solvent action on these materials. The table on page — lists the liquids that may be used on plastic. Soap and water applied with a clean soft cloth or sponge provide the best care for plastics. The surface should be wiped lightly with a soft cloth, and care taken not to rub hard particles into the surface.

CAUTION

Esters, ketones, and aromatic hydrocarbons and chlorinated hydrocarbons should not be used on plastic since they have a definite dissolving action.

The exterior surfaces of the cockpit windows are of glass. These surfaces may be cleaned with a liquid polish thinned with water, and the mixture applied to the window with a mop or cloth. If it is necessary to remove grease or oil from the windows, they are first washed with castile soap or an approved type detergent before the polish is applied. (Refer to the appropriate Maintenance Manual for removing scratches from windows and windshields.)

Polishing aircraft surfaces by mechanical means may be required to remove oxide film and, later, to restore the luster to the surface. Different materials may be used, each with different abrasive grits, to accomplish the particular task.

Heavy polishing to remove heavy oxide film is done with a mild abrasive that is thinned with water to a consistency of thick cream. The solution is applied to the surface with cloths or mops, and agitated with a mechanical polisher until the desired results are obtained. The polisher should be operated with even pressure and travel to accomplish the best job. Final polishing is done by hand, in one direction only, to eliminate the swirling pattern left by the mechanical polisher.

Heavy polishing is not a substitute for cleaning, and should be used only to remove oxidation. The polisher should be handled with extreme care on contours and corners to prevent damage to aircraft skin.

Chemical polishing may be accomplished on unpainted aluminum surfaces. The process, using Chempo, may be used regularly with no danger of damage to the metal.

The surfaces to be chemically polished are first cleaned by wet washing, after which the chemical polishing compound is applied. Brushes or mops are used to spread the chemical lightly and evenly over the surface until the bubbles disappear. The application is allowed to stand for approximately 20 minutes, and then agitated with brush or mop. If the compound dries, it may be moistened with a fine water spray or an additional light spray of the chemical.

After complete agitation, the solution is rinsed off with a high volume, high-pressure stream of water. The surface is rerinsed if necessary to remove remaining spots and streaks. Light streaking may be removed by rubbing with a clean damp cloth.

For corrosion removal, refer to the appropriate maintenance manual.

The accompanying list of cleaning products and the corresponding manufacturers are presented as a handy reference.

Table of Cleaning Compounds

PRODUCT	MANUFACTURER	TYPE	USAGE
AIR-TEC NO. 3	Turco Products Co.	Alkaline	For general cleaning of aircraft exterior surfaces. Diluted with water.
ALUMILOY P	Cee Bee Chemical Co.	Alkaline	For general cleaning of aircraft surfaces. Diluted with water.
OAKITE 74	Oakite Products Co.	Mild Alkaline Detergent	Wet wash solution applied with pressure spray to painted and unpainted surfaces.
OAKITE 202	Oakite Products Co.	Alkaline	For general cleaning of aircraft surfaces. Diluted with water.
TURCO 1526A	Turco Products Co.	Alkaline	For general cleaning of aircraft surfaces.
EMULSO-CLEAN	Cee Bee Chemical Co.	Inhibited Alkaline Cleaner	Wet-wash solution for removal of grease & oil from unpainted surfaces; for removal of carbon deposits.
JET CLEAN NO. 2	Turco Products Co.	Emulsion	For general aircraft washing. Diluted with petroleum solvents and/or water.
AIRMULSO TURCO 2844	Turco Products Co.	Emulsion	For removing oil, grease, and dirt from engines, wheel wells, & landing gear.
AERO-DET A202	Oakite Products Co.	Emulsion	For removing oil, grease, and dirt from engines, wheel wells, & landing gear.
EMULZALL TURCO 3942	Turco Products Co.	Emulsion	For removing carbon and exhaust stains.
PLAUDIT TURCO 3752	Turco Products Co.	Mild Neutral Emulsion	For removal of surface dirt, grease, oil, tar, carbon deposits & exhaust stains from underside of epoxy-painted wings.
TURCO 4395	Turco Products Co.	Non-Phenolic	For removing embedded reverse thrust carbon deposits. Safe on high-strength steels. Toxic.
TURCO 4669	Turco Products Co.	Phenolic Type Stripper	For removing heavy carbon deposits from unpainted metal surfaces. Used full strength.
CHEMPO TURCO 3001	Turco Products Co.	Chemical Type Cleaner	For removing oxidation from metal surfaces. Safe on all metals except magnesium. Safe on paint, glass, Plexiglas, fabrics. Provides lustrous oxide-free finish.
TURCO 3002	Turco Products Co.	Phosphoric Acid	To remove light oxidation and corrosion from unpainted aluminum alloy surfaces.
KLAD	Hollingshead Co.	Mild Abrasive Polish	For removing light oxidation & heavy stain that cannot be removed by cleaning compounds. Restores luster to aluminum surfaces. Used diluted on painted surfaces.
ALUMINU	NuSteel Co.	Liquid Polish	For removing stubborn streaks, discolorations & heavy oxide that cannot be removed by washing. For use on unpainted surfaces.
AEROGROOM	Autogroom Co.	Liquid Polish	For cleaning & polishing; mixed with warm water to remove grime from painted & unpainted surfaces.
JOHNSON'S 5015	Johnson Wax Prod.	Clear Water Emulsion Wax	Thin film protects surface & facilitates removal of reverse thrust carbon deposits from painted surfaces.
VARSOL	Standard Oil Co.	Petroleum Solvent	For removing dirt, oil, grease from Alclad & stainless steel surfaces. May be used as solvent with other cleaners.
NUTOWEL	American Wiper Waste Co.	Cleaning Tissue	For applying cleaner to plastic & glass windows.
CASTILE SOAP	Commercial	Mild Soap	For cleaning non-water soluble soils from plastic windows.
DUPONT NO. 7	DuPont deNemours	Cleaner and Polisher	For non-oily dusty Plexiglas. Diluted with water.
GLASTICOTE 18	R. Killian Co.	Plastic Window Cleaner	For removing oil and grease from plastic windows.
PERMATEX	Permatex Inc.	Glass Cleaner	For cleaning glass surfaces. Applied full strength with soft clean cloth.
WINDSHIELD CLEANER	Air Associates	Liquid Cleaner	For cleaning glass surfaces.

Cabin Pressure Regulator (Outflow) Valves

TWO AIR PRESSURE REGULATOR (outflow) valves are incorporated in the cabin pressurization systems of the 880, 880M and 990 jet airliners. Each valve has sufficient capacity to handle entire cabin air flow requirements, assuring continued full operation in the event of malfunction of one valve.

Normal operation is solely pneumatic and automatic, being regulated by air pressure, and programmed from the cabin pressure controller on the flight engineer's control panel. The valves sense cabin air pressure and pressure differentials, and close or open, as required.

The manually-operated system with a motor-driven override is actuated from the flight engineer's control panel. The override system operates from the 28-volt dc emergency bus, and permits the flight engineer to control positioning of these valves. Two amber indicator lights illuminate whenever the valves are in the closed position.

Several safety features are built into the valves; for instance, automatic pressure relief and vacuum relief are provided. In addition, if one or both valves should fail in the open position, a pressure limiting device within each valve closes the valve enough to maintain a cabin altitude of 13,000 ±2,000 feet.

Conversely, if the cabin pressure differential reaches 8.50 psi, either or both outflow valves will open to serve as a pressure relief system. A vacuum condition of 0.36 psi will automatically open the valves to equalize the pressure.

Orifice filters in the valves prevent entrance of dirt, tobacco tars, etc, which could cause the valve to stick or become sluggish. The forward valve installation, located on the floor of the electronics compartment, is provided with an external protective screen clamped around the inlet area to prevent blocking of air flow by the electronic compartment curtain in the event the curtain should become detached.

The aft valve is located below the aft buffet. The vacuum source for operating the valve is supplied from a venturi in the lavatory area of early 880's, and in the buffet in later 880's and in the Convair 880M and 990.

The cabin air pressure regulating valves, an outgrowth of earlier valves, incorporate improvements resulting from operational and maintenance experience.

In summary, the system provides dual full capacity operating capability with manual override control, and complete automatic safety features, resulting in a minimum of maintenance.